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ABSTRACT:

The Military Airlift Command(MAC) is faced with an ever-increasing pilot retention problem. In recognizing this problem, MAC submitted a Strategic Airlift Aircrew Survey (SAAS) to the MAC aircrew members in 1977. The results of the SAAS indicated that an unstable flying schedule was a primary cause of the high voluntary pilot separation rates. This thesis has examined the MAC flying schedule to determine if there are any relatively predictable elements to the schedule. The authors have taken the predictable elements and have devised techniques for employment at the squadron level to create additional stability in the pilots' flying schedule. The areas of predictability were determined through the use of normality and T-Tests. Regression analysis was then employed to aid the squadron's pilot scheduler in preparing a complete monthly flying schedule prior to the beginning of the affected month. If increased stability in the schedule is achieved, pilot retention rates should increase dramatically.

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A STRATEGIC AIRLIFT PILOT SCHEDULING TECHNIQUE UTILIZING STATISTICAL ANALYSIS

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degrees of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(INTERNATIONAL LOGISTICS MAJOR)
(Captain Dean H. Haylett)

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Captain Craig W. Spiess)

DATE: 9 June 1980

Thomas C. Harrington
COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

The United States is presently at peace. The Vietnam conflict is past, although many of the consequences of that conflict remain. One of the main consequences of the Vietnam period was the abolishment of the conscription of young men into the military service. As a result, the military forces have been forced to try harder than ever to obtain and retain highly qualified personnel. The United States Air Force is a main participant in this drive to maintain a quality force. During the years of the military draft, the Air Force had little or no trouble meeting its recruitment quotas and maintaining a quality force. Since, 1975, however, this trend has reversed. The Air Force has experienced both decreased recruitment and an ever-increasing separation rate of its highly qualified personnel, most notably the pilot force. The Command which has received most of the attention in the retention discussion is the Military Airlift Command (MAC).

MAC is the main supplier to all the United States military services in the world for priority items, perishable goods, mail, and troop transportation. As a Specified Command, MAC is directly responsible to the Joint Chiefs of Staff. During an emergency situation, MAC forces will be directed to accomplish the airlift of the initial items required for resupply and reinforcement of all the combat forces of the United States.

This necessary airlift capability is being threatened by the departure of many of MAC's pilots. The pilot loss rate for strategic airlift is one of the highest in the entire spectrum of pilot categories. As will be explained later in this research, this situation is not likely to reverse itself soon.

The importance that the senior leadership of the Air Force attaches to the pilot retention problem can be observed by reading the following text of a speech by General B. L. Davis, the Commander of the Air Training Command, to the Daedalians Longhorn Flight banquet:

> No personnel issue is more alarming, and none carries greater symbolic impact, than an Air Force that is losing its pilots.... What concerns me most, is not the loss of a pilot capable of flying a mission, but the far greater loss of an irreplaceable cadre of experienced and potential leadership in middle-management ranks.... That loss would eventually affect our senior leadership ranks. We can put someone into a trainer cockpit and have that person flying a mission in a year or two, but we can't replace 11 years of operational experience and skills in any time short of 11 years [4:8].

STATEMENT OF THE PROBLEM

MAC is now faced with the departure of over 82% of its younger pilots to the civilian sector in general and the commercial airlines in particular (3:3). Since the commercial airlines perform a function similar to MAC, transporting people and cargo throughout the United States and the world, the problem of pilot retention in MAC is not predominantly that of pilots not wanting to fly, but that of the pilots' perceptions of the advantages that the airlines have over MAC.

One advantage enjoyed by the airline pilots is a relatively firm schedule that each pilot knows well in advance. Because the MAC pilot enjoys no such firm schedule, his personal stability is adversely affected. As time progresses, the MAC pilot is continually forced to rearrange his schedule to accommodate new flying demands. (Throughout this research, the use of the male pronoun may be considered to eventually encompass female pilots. Women pilots are not yet eligible to separate from the service owing to their recent entry into the pilot force, but they will eventually face similar career decisions.) The pilot perceives that the commercial airlines offer a more stable monthly flying schedule. An airline thus becomes an organization that offers both the type of flying that a MAC pilot wants and an atmosphere that will allow him to better preplan his non-duty activities.

MAC has recognized that this problem with its schedule has caused pilots to leave the military. MAC has tried several approaches in an effort to solve this problem.

This research will approach the scheduling problem from a different direction to offer the tools to create a more workable schedule for the strategic airlift pilots in the Military Airlift Command.

SCOPE

MAC has four basic types of airlift: strategic, tactical, aeromedical, and VIP support. Although the work schedules and the flying missions may be periodically similar for the four types, this research will be limited to a study of the strategic airlift portion of MAC. The two aircraft that comprise the strategic airlift element of MAC are the C-141 Starlifter and the C-5 Galaxy. C-141 aircraft are operationally deployed at McGuire AFB, McChord AFB, Charleston AFB, Norton AFB, and Travis AFB. C-5 aircraft operate out of Dover AFB and Travis AFB.

This research will concentrate on pilots that have at least six years and less than eleven years of military service. Pilots with less than six years service are still obligated to the Air Force. Pilots with more than eleven years of service have probably been promoted to major and can reasonably expect to remain in the active force until retirement. The group in the middle, six to eleven years, is the group that is most in the position to separate from the service, and the issues affecting pilot retention are more commonly geared to this group. Since the six to eleven year groups are the nucleus for the middle-managers of the Air Force, the concern over their retention is Air Force wide.

All of the retention figures to be mentioned will be for this six to eleven year group. A retention figure of, for example, 40% indicates that of all the pilots that have at least six years of service, 40% have stayed in the Air Force through their eleventh year of service.

BACKGROUND

AUTHORS

The authors of this thesis have had a great amount of experience in the strategic airlift environment and have had many prior discussions with pilots about the subject of this thesis. Captain Dean H. Haylett is a former strategic airlift navigator. He has been an aircrew member on the C-141 for more than five years. In addition to his primary duties as a "gator," Captain Haylett has served as a Wing Operations Officer at the Travis Consolidated Command Post, the initial navigator at Travis AFB to be so assigned. In this capacity, Captain Haylett has worked closely with all the key personnel that schedule and revise MAC missions. Captain Craig W. Spiess is also a navigator whose most recent assignment was as a strategic airlift navigator at Travis AFB. Captain Spiess's additional duties included Squadron Scheduling Officer, Squadron

Instructor Navigator, Squadron Standardization and Evaluation Flight Examiner Navigator, Wing Combat Airdrop Mission Planner and Coordinator, and Wing Standardization and Evaluation Flight Examiner Navigator.

PILOT SCHEDULE

The work schedule of a strategic airlift pilot in a MAC squadron consists of considerably more than just flying. There are additional duties, ground training, and a host of other time-consuming meetings and formations that must be met. The most unstable element in the schedule of the pilot is the flying schedule. There are two basic categories of missions for a MAC squadron's flying schedule: firm scheduled missions, those missions preplanned and printed on the monthly Wing Operations Plan (WOP); and add-on missions, those missions generated throughout the month which are not preplanned. The firm scheduled missions include channel cargo and passenger missions, aeromedical missions, and combat airdrop missions. Add-on missions include special airlift missions, emergency evacuation missions, and the reconstitution of standby forces. Add-on missions are commonly considered to adhere to the "you call, we haul" concept in MAC mission planning.

OBJECTIVES

This research will be concerned with four objectives. First, all missions will be examined to determine if they return to home station on time. Second, an examination will be made of the add-on missions to determine if their mission length can be reliably anticipated prior to mission set-up. Third, all missions will be examined to determine if there is a direct relationship between their scheduled mission length and their actual mission length. Finally, the results of the first three objectives will be utilized to determine if there are general scheduling techniques that can be devised to firmly establish a strategic airlift squadron's pilot flying schedule prior to the start of the scheduled month. If these objectives can be realized, then a better schedule can be assembled, and hence, the squadron's pilot assets can be better utilized.

JUSTIFICATION

PILOT RETENTION

The table on page 8 reflects the total pilot retention figures for the six to eleven year group over the previous three and one half years. The figures exhibited in this table reflect pilot retention in the United States Air Force, generally, and in the Military Airlift Command, specifically. It is estimated that the Air Force must retain

TABLE 1

PILOT RETENTION

FY	USAF	STRATEGIC AIRLIFT
1976	50.6%	32.2%
1977	49.7%	28.6%
1978	39.6%	18.2%
1979 (1st Half)	30.2%	17.6%

SOURCES: (3:3; 15:2)

at least 57% of the pilots that graduate from Undergraduate Pilot Training (8:15; 16:1). As the table indicates, not only is this fugure not met, but the trend is moving decidedly in the wrong direction.

SCHEDULING INSTABILITY

In November of 1977, the Airlift Manning Center at the Air Force Military Personnel Center (AFMPC) at Randolph AFB, Texas, conducted a "Strategic Airlift Aircrew Survey," SCN 77-157. This survey was conducted to "obtain opinions and attitudes of strategic airlift aircrew members concerning their career area (14:i). Of the 20 alternative responses that were available for selection, the number one response given for reasons why a younger pilot would want to separate from the military service was "Work schedule instability." In total, 43.1% of the aircrew members that were polled indicated that an unstable work schedule was one of their top three concerns (10:39). This survey will be examined in greater depth later in this research.

RESEARCH QUESTIONS

The specific questions to be addressed and answered in this thesis are the following:

1. Do off station missions return to home station when they are scheduled?
2. Can the length of time away from home station be reliably scheduled for add-on missions prior to mission set-up?
3. Is there a direct statistical relationship between scheduled mission length and actual mission length?

CHAPTER II

LITERATURE REVIEW

INTRODUCTION

This chapter will present the reader with the events and situations which have caused much of the problem with pilot retention in the Military Airlift Command (MAC) today. A presentation of previous attempts to solve this problem is also included. This chapter will first explore the background for the scheduling problem. Then, an extensive review of the specific reasons for pilot dissatisfaction with various elements of his job in MAC will be conducted. Third, an examination will be made of the private commercial airlines, the "competition," and why the MAC pilots are leaving the service to join them. Finally, the three previous attempts to stabilize the MAC schedule will be examined.

BACKGROUND

MAC is unlike the other operational commands in that its peacetime mission is not radically different from its emergency and wartime mission. Whereas the outputs of the Strategic Air Command and the Tactical Air Command change considerably from a peacetime to a wartime environment, MAC's change in output is limited to a change in the intensity of airlift during a given period of time and the urgency of timely delivery for the majority of cargo and troops that are being transported. As a result, MAC has a tradeoff in its stability of operations. Whereas the overall operation of airlift would not change drastically in a shift from peacetime to wartime, the day-to-day operations of MAC during peacetime need to be highly flexible and cannot be forecast in advance with any great degree of surety.

This instability in the daily schedule is caused by numerous events, some of which can be controlled and some of which cannot be controlled. Certainly, the persons who schedule missions from MAC headquarters on down through the chain-of-command to the squadron crew position scheduler have some control over mission priorities, aircrew usage, and the daily requirements for airlift. However, these same persons have no control over weather, maintenance capability of the aircraft, or emergency airlift requirements. This research will not presuppose that a perfect schedule for the strategic elements of the Military Airlift Command can be assembled. Rather, the authors will point to the areas that could be forecast with relative ease and accuracy and to how this knowledge could be used to stabilize the monthly schedule of MAC crew members, specifically the schedule of the squadron's pilot force.

PILOT RETENTION

Pilot retention has been the subject of a number of recent studies. Usually, the first question to be asked and answered is why the younger pilots are leaving the Air Force. The next relevant question is how can the Air Force slow or even stop the junior pilot from leaving the military. Unfortunately, most of these studies have considered only one or two of the myriad of reasons that a young pilot could state as the reason why he chose to separate from the service. This research will also be limited to one crucial reason for the lack of strategic airlift pilot retention. However, the reader is cautioned that the authors do not consider the solution to this portion of the pilot retention problem to be an overall panacea, a cure-all.

VALUES

A recent master's thesis submitted at the Air Force Institute of Technology emphasized the value differences that pilots perceive exist between themselves and their organizations. This research considered the pilots who happened to be attending Squadron Officers School (SOS) Class 78A. This study utilized the Rokeach Value Survey Instrument. Stability will be examined as an example of the differences between personal values and perceived organizational values. Although stability was not specifically addressed by the Rokeach test, two values that

Rokeach defined are consistent with stability. Happiness was defined as contentedness and Inner Harmony was defined as freedom from inner conflict (5:18).

The SOS pilots were requested to rank order eighteen values as they saw these values for themselves and then to rerank these same values as they perceived them to be important for the organization of their last command. The differences between the ranks of these two values suggest that the pilots perceive great incompatibility in their outlook for values in themselves and in their organizations. Happiness was ranked number four by the pilots for themselves and number twelve for the major commands. Inner Harmony was ranked number seven by the pilots for themselves and number thirteen for the major commands. The pilots' desire for stability was not perceived by them to be important to their organizations. The pilots were also separated by Commands for the previously mentioned thesis and MAC pilots were very close to the rankings for all the other pilots (5:43-51).

SEPARATION REASONS

In 1977, the Air Force Military Personnel Center (AFMPC) conducted a Strategic Airlift Aircrew Survey (SAAS) to try to ascertain why strategic airlift pilots and other crew members would desire to separate from the service. The table on page 15 lists the reasons that were offered

TABLE 2

REASONS FOR SEPARATION

LETTER	REASON
a.	Not applicable, I intend to remain in the Air Force
b.	Work schedule instability
c.	TDY expenses
d.	Performance evaluation system (OER/APR)
e.	Security of future uncertain
f.	Inadequate military pay and allowances (including incentive pay)
g.	Lack of career progression/development opportunities
h.	Lack of opportunity to exercise independent judgment
i.	Threat to or apparent loss of benefits (except retirement system)
j.	Family disruptions due to job
k.	Excessive non-flying work requirements
l.	Uncertain future of retirement system
m.	Limited promotion opportunities
n.	General dislike of the Air Force as a way of life
o.	Assignment instability
p.	Air Force management and policies
q.	Received an undesirable assignment
r.	I entered the Air Force for training and never really considered making it a career
s.	I received a civilian job offer
t.	Other (please specify on comment sheet)

SOURCE: (14:7)

for consideration and selection to the aircrew members by the AFMPC.

Of the 1152 pilots who could have responded to this survey, 740 answered for a response rate of 64%. Each of the six operational wings in MAC was well represented in the total response rate (10:20). The exact text of the questions relating to retention and the results for each question are stated in the table on page 17.

Response b., "Work schedule instability," is the number one overall response, and hence, the number one stated reason for separation. In all, about 43.1% of the respondees indicated that an unstable schedule was in their top three reasons to separate (10:39). Additionally, other responses such as "Air Force management and policies" and "Family disruptions due to job" can be at least partly attributed to scheduling instability.

SEPARATION RATES

Pilot retention problems are not due to scheduling problems alone. Yet, the impact from the cumulative forces that cause the younger pilot to separate from the military service have resulted in unprecedented voluntary separation rates for MAC. Strategic airlift pilots have consistently had one of the highest separation rates over the past three years. The table on page 18 exhibits the loss rates for the last three years for which data were collected. As can

TABLE 3

STATED REASONS FOR SEPARATION

If you plan to separate from the Air Force prior to retirement, which of the reasons listed below do you consider most important in your decision to separate?

RESPONSE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY
b. Work schedule instability	79	18.2%
p. AF management and policies	63	14.5%
e. Security of future uncertain	53	12.2%
j. Family disruptions due to job	45	10.3%

Using the same list of responses from question 47, what is the second most important reason in your decision to separate? (If there is no second reason, select response U.)

RESPONSE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY
b. Work schedule instability	72	16.6%
j. Family disruptions due to job	50	11.5%
f. Inadequate military pay	41	9.4%
e. Security of future uncertain	36	8.3%

Using the same list of responses from question 47, what is the third most important reason in your decision to separate? (If there is no third reason, select response U.)

RESPONSE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY
p. AF management and policies	46	10.6%
b. Work schedule instability	36	8.3%
e. Security of future uncertain	33	7.6%
f. Inadequate military pay	33	7.6%

SOURCE: (10:39)

TABLE 4

USAF PILOT RETENTION RATES

6-11 YEAR AVERAGE BY WEAPON SYSTEM GROUPS

SYSTEM	MAR 77	MAR 78	MAR 79	JUN 79
AVERAGE	52.2	46.3	30.2	26.9
TRAINING	38.4	43.6	22.2	16.4
STRATEGIC AIRLIFT	34.7	22.4	17.6	17.3
TACTICAL AIRLIFT	49.6	49.5	25.0	20.6
TANKERS	53.1	43.3	24.1	21.4
RECCE	68.7	51.7	33.5	28.8
BOMBERS	64.2	61.3	41.7	36.3
HELICOPTERS	45.8	64.4	46.2	40.2
FIGHTERS	75.3	61.0	43.4	41.2

SOURCE: (8:31)

be readily seen, the retention rates for all categories of pilots is well below the Air Force goal of 57%. In fact, pilots of training aircraft and strategic airlift aircraft are retained at a rate of less than one-third the desired rate. It is also evident from Table 4 that the retention rates for nearly all pilot categories have been roughly cut in half in the 27 months from March of 1977 to June of 1979. Although pilots of trainer aircraft currently lead the exodus from the military, strategic airlift pilots are a close second and have always been at the forefront of the retention problem.

PILOT INVENTORY

The loss rates which have occurred have only recently impacted on the capability of the Air Force to accomplish its mission. Figure 1 on page 20 indicates that the inventory of pilots is now considered to have dipped into staff and supervisory personnel in order to be fully capable in an emergency situation. This estimate of pilot requirements versus pilot inventory makes one questionable projection. The inventory line which specifies current pilot strength is estimated to level out over the next five fiscal years. Although this projection is possible, it is more likely that the decreasing slope to the line will not cease at 1980, but will continue to some degree through 1985. This possibility was delineated in an Air Force

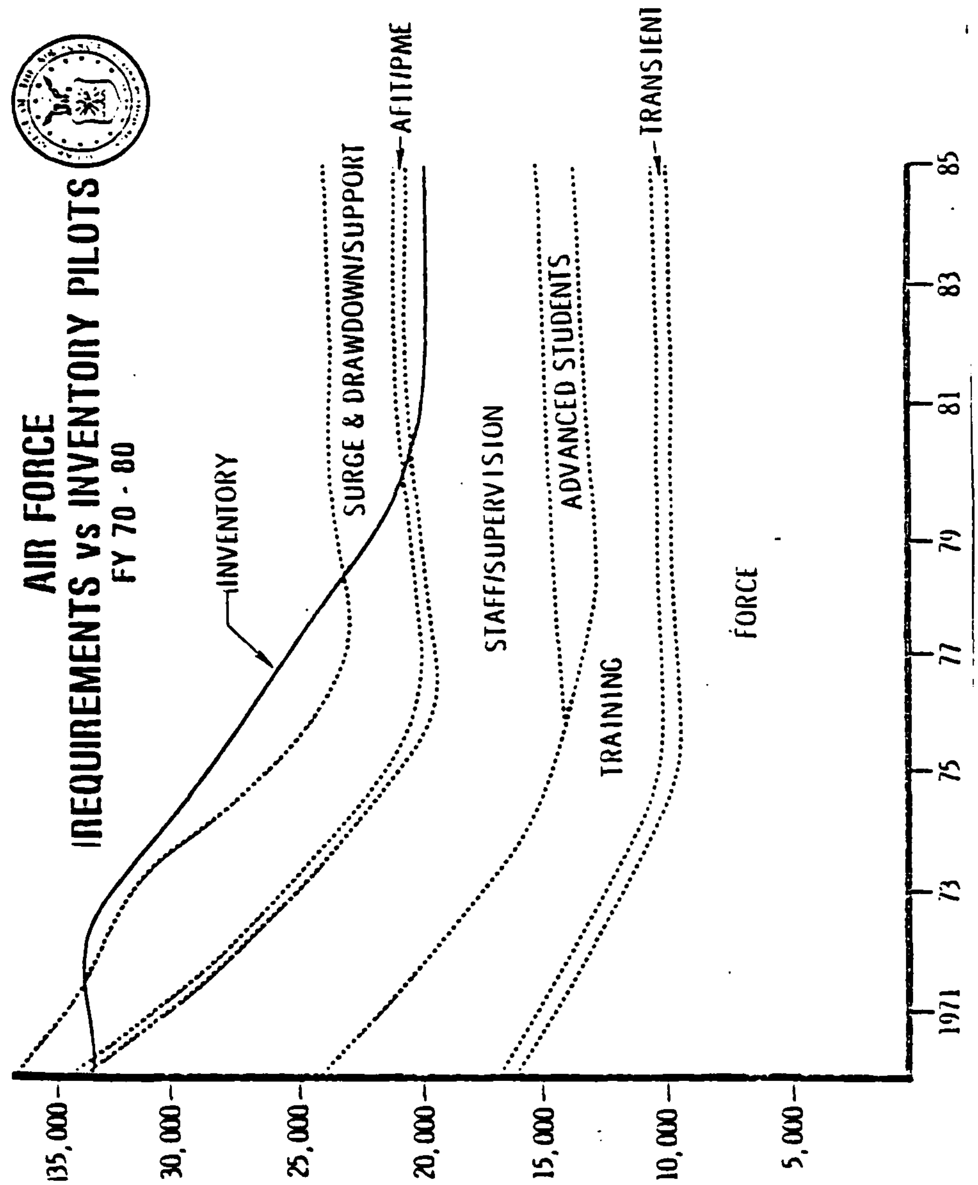

Fig. 1. Air Force Pilot Inventory

Long-Range Personnel Policy Perspectives briefing in early 1980:

> This chart shows graphically the requirements versus the inventory, indicating that by 1985, _if we continue to retain at the 1979 rate_. we will be not only well below our authorized strength, we will be cutting into the bone. If retention declines further, say to the levels in the Navy, we will cut further into the bone [8:16].

COMMERCIAL AIRLINES

Nowhere in the research for this thesis has there been any indication to the authors that a significant number of pilots leave the service because they dislike flying or even because they dislike military flying. Unlike the vast majority of pilots in the civilian sector, a MAC pilot has the opportunity to fly to almost any point on the globe on any given mission. It is very probable that a MAC pilot could fly to all the earth's continents (including Antarctica) and come in contact with nearly all the peoples and cultures of the world. The authors believe that this is a large drawing card for MAC. The reality that MAC has an extremely high separation rate indicates to the authors that the opportunities outside of MAC are weighted much heavier than the advantages of flying for MAC.

When a MAC pilot separates from the service, he can continue to be employed as a pilot in one or more modes. First, he can be employed by industry by flying general aviation aircraft. Second, he can join the Air Force Reserves and fly the same missions with the same aircraft that he used to fly as an active Air Force pilot. Finally, he can be hired by one of the commercial airlines.

JOB AVAILABILITY

Over the past three years, until just a few months ago, the airlines have had a strong upsurge in the hiring of new pilots. The primary reason for this increase in hiring is that many of their senior pilots who were hired during the post World War II period are reaching the mandatory retirement age of 60 (16:4). These pilots must be replaced. The easiest, least expensive, and very willing source for pilot replacements are the young pilots of the military and specifically MAC, since the transportation mission and the type of aircraft are similar.

Presently, the country is (depending on one's political and economic viewpoint) somewhere in the cycle of an economic slowdown, commonly known as a recession. The commercial airlines have been affected by the recession to the extent where some airlines are halting the hiring of new pilots and some are even laying off some of their pilots with the least amount of seniority (2:1). The authors of this research firmly believe that when the economy turns and growth commences again, the hiring away of Air Force pilots by the airlines will exceed anything that the Air

Force has experienced before. The reason is simple. More and more airline pilots will come due for retirement during this recession. When the airlines perceive that they can hire again, they will have to recover from the lack of hiring during the recession as well as hire to anticipate their proposed retirements. If this re-vitalized hiring starts in the late 1980 time-frame, approximately 1200 to 1500 airline retirees will have to be replaced immediately. This trend will not dissipate. An average of about 750 pilots will retire during each year of the 1980s and about 1600 pilots will retire during each year of the 1990s. These figures compare with 300 retirees in 1976, 523 in 1977, and 667 in 1978 (16:5).

In addition to the mandatory retirees, the airlines will undoubtably lose some pilots due to medical problems, disability problems, or early retirements. There is also increased competition caused by the initial lowering of fares that occurred due to the passage of the Airline Deregulation Act of 1978. This increased competition has fostered an increase in the demand for routes, planes, and pilots (16:4). However, the continuing fuel crisis has had a severe impact on the expansion plans of the airlines. The overall result of the fuel emergency may alter the equation and stifle the increased demand for route diversification. In spite of this, the authors contend that once the airlines have had time to adjust their fares and services, the recent cut-back in routes will be reversed. In sum, these facts and opinions point to the likelihood that the heavy hiring of MAC pilots over the last three years was not a passing fad.

AIRLINE PILOT SHORTAGE

The previous figures on the needs of the airlines for pilots are significant in themselves, but another relevant factor cannot be ignored. With the end of the Vietnam conflict, the Air Force senior leadership decided that the overall pilot requirements would be less in peacetime than they had been during the conflict. Hence, the pilot pipeline was severely constricted. Figure 2 displays the pilot demands of the airlines versus the combined availability of pilots for the 1974-1990 time-frame with the projection for airline requirements through the year 2000. It is evident that even if every pilot who served out his initial commitment was to separate to fly for the airlines, there would still be a short-fall of several hundred pilots on an annual basis. This facet was addressed at the Air Force Long-Range Personnel Policy Perspectives Briefing:

> The last long term problem we explored is rated retention...we anticipate this drain to continue at least into the 1990s because the airlines will be hiring upwards to 3000 pilots a year through that time period.... This chart shows that the airline demand into the future could be greater than the number of Air Force or Navy pilots completing their initial obligation to the service. It is based on MAC's

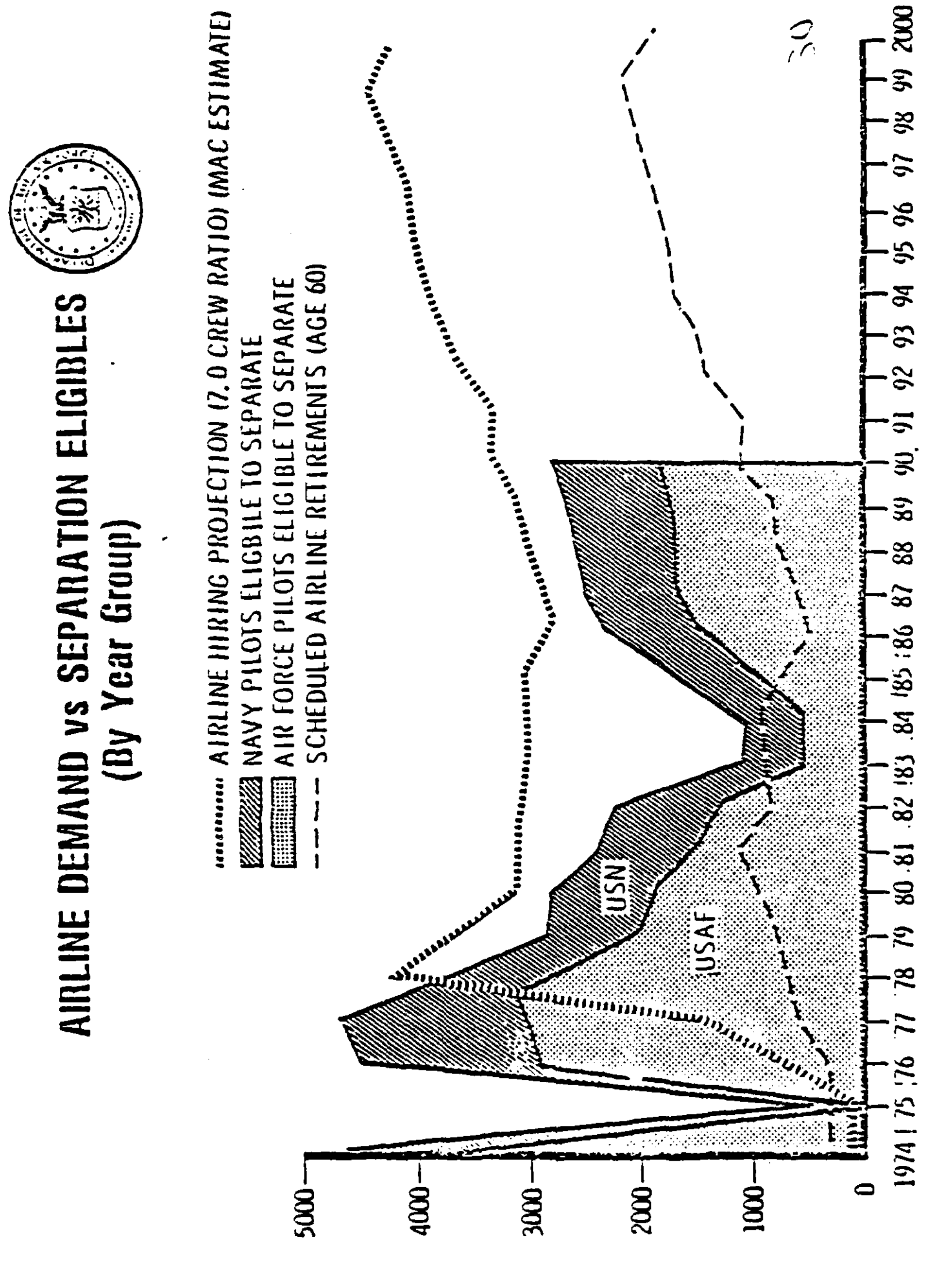

Fig. 2. Airline Demand Versus DOD Availability

estimate of pilot demand given expected expansion in the airlines based on equipment purchase options placed and a crew ratio of 7.0 crews per aircraft [8:14-15].

Added to the airlines as a potential retention competitor, pilots are also needed by industry for general aviation. In sum, the Air Force faces two decades of the continual loss of its pilots and the strategic airlift pilot will continue to be highly demanded (16:6).

PAY DIFFERENCE

One alternative that the MAC pilot has to the military has been stated to be the commercial airlines. A quick examination of the airlines shows a number of advantages that a commercial airline pilot enjoys over his MAC counterpart. The most impressive comparison is pay. Although the airline pilot faces a first year period of relative pay drought, an industry average of about $8100, pay quickly triples in the second year to approximate a MAC pilot's pay (Captain with greater than six years service). The average Second Officer, two to six years, earns about $30,000 a year. The average First Officer, seven to sixteen years, earns about $41,000 a year. The average Captain earns about $60,000 a year if he pilots a smaller jet (B707 or B727) or $70,000 to $80,000 a year if he pilots a jumbo jet (B747 or DC10). These figures will be about 10% to 15%

less for a local airline, but even these wages are well in excess of a military pilot's pay (16:9).

The problem of a pay difference was addressed in a student research report submitted to the Professional Military Comptroller Course at the Air University, Maxwell AFB, Alabama. The author of that report proposed a pay formula that would decrease the huge pay difference between the military and civilian pilots. The author's solution may or may not assist in stemming pilot separations (13:14). The authors of <u>this</u> research do not believe that pay or any other <u>single</u> element is a cure-all for the pilot retention problem. Although this research centers on the scheduling problem, the pay issue cannot be ignored.

SCHEDULING DIFFERENCE

The second main difference between military and civilian flying (and the topic of this thesis) is the stability in the scheduling of aircrews. The results of the Strategic Airlift Aircrew Survey demonstrated that the MAC pilots considered the unstable schedule to be a greater deterrent to remaining in the Air Force than any other single reason, including pay.

The MAC scheduling process starts 120 days in advance for passenger missions and 90 days in advance for cargo missions. The initial schedule is based on <u>estimated</u> user requirements (9:10). This estimation is tabulated from past requirements and what the user foresees as his needs. Only a small number of missions can be accurately established during this phase of the scheduling process. There is no way to accurately forecast the time when cargo will actually arrive at the terminal, usually by truck or train.

Nearly all specific documentation and load planning occurs after the cargo actually arrives at the port. This arrival normally takes place within a few days of the planned mission date (9:11). Hence, the original schedule and subsequent crew requirements are initiated as much as 120 days prior to the time when the planners would know with certainty that a mission is truly required. If the cargo does not come into the port as anticipated, some missions will have to be cancelled and some missions will have to be added on to the schedule at a later date. These add-on missions are usually planned on short notice, normally with one to three days lead time.

Despite the apparent shortcomings of this system of scheduling, advanced planning based on only assured missions would be nearly impossible to implement because MAC's overall schedule needs to be flexible enough to adjust to any short notice airlift requirement. MAC's existence is pegged to the desire of the Department of Defense to be able to transport people and cargo to any and all parts of the world with minimum notice. In fact, MAC's current system of advanced planning is quite good because the regular users of MAC's services continually funnel cargo to MAC's ports and the combined services rotate a consistent number of people to and from their overseas installations. This continual pipeline of cargo and personnel allow MAC's planners to be more flexible (9:11).

Yet, instability remains in the MAC schedule. The people affected most by this instability are the MAC aircrew members. In contrast to MAC, the pilots of the commercial airlines use a bid system on a monthly basis to schedule their crews. Each month, all of the pilots of an airline bid for the various routes available to them. The bidding is done by crew position and seniority. Even the newest pilot knows when he will be on duty and when he will be on his own time. The newest pilots usually have to stand alert during some part of each month in case one of the regular pilots cannot fly. However, even this alert period is a firm scheduled period. The younger pilot has to endure this for only a short period of time, depending on the airline's policies and the availability of newly hired pilots. The individual airlines have their own special quirks in implementation of the system just described, but the general system of scheduling is nearly universal to all the commercial airlines (1).

SCHEDULE STABILIZING ATTEMPTS

MAC has not been blind to its scheduling problem and three attempts to provide stability to the strategic airlift schedule as well as accomplish other objectives have been tried in the last six years.

FLIGHT COMMANDER AND NUMBERED CREW SYSTEM

The Commander of MAC, General Paul K. Carlton, implemented the Flight Commander and Numbered Crew System throughout the Command in January of 1974. At the working level, this method of scheduling became known as the Hard Crew System or Integral Crew System (13:19). General Carlton's objective for this system of scheduling was "to provide greater effectiveness in the management and supervision of the aircrew force (13:19)." The basis for this system was the Strategic Air Command's (SAC) system of crew control. The aircrew schedule in SAC was designed to be extremely stable. The schedule was developed over a three-month period and was continually refined throughout this period. When the final schedule was posted, about five days prior to implementation, the crews knew exactly what they would be doing throughout the following month. Of course, some deviations would occur due to illness, leave, etc., but the majority of SAC's crew members were assured of flying, training, being on alert, crew resting, and being off duty on the previously scheduled days (13:32-35).

In contrast to this, MAC did not have then, does not have now, nor will likely have in the future, the rigid stability in its schedule such as that possessed by SAC. The reason for this is that SAC has complete control over its mission in peacetime whereas MAC has other forces to contend with. In SAC, there is no such thing as a user paying for the performance of SAC's mission. On the other hand, MAC is sometimes at the mercy of the user, the agency or company paying for the mission. If the user is not ready for pick-up or delivery, a MAC mission will have to wait for the time when the funded mission is ready to move (9:4-5). Whereas SAC can cancel a mission for weather, MAC must wait for the weather to improve and then complete the transport. The overall impact of this problem was summarized by a C-141 squadron commander in April of 1974:

> A second contributing factor is that the changing requirements and priorities of the strategic airlift mission prevent firm scheduling return dates and completion of crew rest so as to interface with ground training, additional duties, leave, or another operational mission. The fluctuations of the monthly AOD [in reality the Wing Operations Plan] compounds the scheduling in that unknown requirements must be scheduled and some missions scheduled do not operate. This turmoil can be contributed in part to the energy problem but the scheduling reliability and the ability for managers to plan ahead is where the brunt of the problem impacts. Quoted in [10:36]

The Flight Commander and Numbered Crew System was designed to have an aircraft commander, co-pilot, navigator, two flight engineers, and one or two loadmasters fly as a team. There were several methods of substitution designed into the system to compensate for one or two members of the crew not being able to fly on a given mission (13:24-25). As time proceeded, these substitutions became the rule and not the exception. The stated objective of the Flight Commander and Numbered Crew System, lower level management of the aircrew force could not be achieved (13:42).

Due to the variability of crew member scheduling and the failure to achieve increased crew management, the Flight Commander and Numbered Crew System was abolished in 1977. In the authors' opinion, the fault with this system lay not with the concept, but with the trouble in implementing this system into the MAC environment.

At about this time, pilot separations to the airlines increased to unacceptable proportions with strategic airlift pilots leading the way out of the military cockpit. The SAAS was conducted and scheduling stability was given a higher priority by the new Commander-in-Chief of MAC, General William G. Moore Jr. Two different programs were devised to try to stabilize the schedule. First, the Fixed Generation Cargo scheduling system was created. This system was centered on stabilizing the mission requirements. Second, the Wild Card Scheduling system for aircrews was implemented, more or less, throughout MAC. These two programs will be discussed separately.

FIXED GENERATION CARGO

The Fixed Generation Cargo scheduling system was implemented on a test basis in November of 1978. Twenty-Second Air Force (22AF), the responsible unit for half of MAC's world-wide cargo transport requirements, based its schedule for channel missions in November on the best available cargo transportation requirements information as of 15 October 1978 (15:6). For the purposes here, a channel mission is defined as a mission scheduled on a regular basis, over an extended period of time. 22AF operated these missions is accordance with a message from MAC headquarters which stated:

> No additions, deletions, reroutes, or in system selects are authorized during the November test period. Emergency requirements will be addressed individually [15:1].

Simply stated, the November missions for 22AF would be flown as scheduled in the November operations plan.

The purposes of this test were two-fold. One, the test was designed to reduce turbulence in the crew force that resulted from changing mission requirements. Two, the test would evaluate the effects of fixed channel cargo operations on the movement of passengers and freight (15:2).

Of the 1806 channel missions flown, only 11% were altered by management (22AF) for a variety of reasons including weather, aircraft maintenance, flood relief, and the cancellation of requirements at enroute stops (15:7). During this test period, cargo generation occurred at less than the expected rate, causing excess capability to be worked into the system. Due to this excess capability, no add-on home station missions were required for channel cargo during November, significantly below the previous average of twelve add-on missions per month (15:8).

The primary task of the November, 1978, test was to determine if scheduled aircrew return rates could be met. The table on page 35 shows the results of this portion of the November test. These results are compared to the figures for the average of the previous three months and with the month of November as a whole, including Twenty-First Air Force missions which were scheduled normally. The lack of a demonstrated improvement in crew return rates forced the early termination to this approach in stabilizing the aircrew schedule.

<u>WILD CARD SCHEDULE</u>

The current attempt to stabilize the aircrew schedule is known as the Wild Card Scheduling system. It has been in operation for approximately two years. This system is designed to rotate levels of stability in working schedules among the flying squadrons at a MAC base. Each squadron is designated as a "firm," "buffer," or "wild card" unit. These designations are rotated among the squadrons on a

TABLE 5

CREW RETURN RATES

AIRCRAFT/PERIOD	CREWS	SRT	FSRT
AUG/SEP/OCT			
C-141	1289	62%*	91%
C-5	227	35%	74%
NOVEMBER (ALL)			
C-141	398	65%	91%
C-5	71	34%	75%
NOVEMBER (FIXED)			
C-141	215	63%	90%
C-5	45	18%	64%

SRT - Scheduled Return Time: Mission Scheduled Return Time

FSRT - Firm Scheduled Return Time: Scheduled Return Time plus 24 or 48 hours pad for Maintenance, Weather, or Priority Diversions

* - 62% means that 62% of the crews during the period of August through October returned to home station on or before their SRT.

SOURCE: (15:3)

monthly basis so that each unit will have a schedule associated with each type of designation during a three-month period. Total flying time is programmed to be equitable among the squadrons, but the type of mission is different according to the monthly designation (7:1-2).

The firm unit receives all its missions from the monthly Wing Operations Plan (WOP). These missions are about two-thirds of the total missions that are scheduled in advance by the Current Operations unit in each wing. The wild card unit receives about two-thirds of the add-on missions that are scheduled throughout the month. In theory, this unit has no advanced schedule but must be ready for any possible priority or time-sensitive mission. The buffer unit is assigned missions that overflow from the other two units. This unit has about half of its missions scheduled in advance via the WOP and about half of its missions added with short notice. The amount of stability, flexibility, and flying time should average out to be about the same among the squadrons over the entire three-month scheduling period (7:2).

At the Air Force Institute of Technology School of Systems and Logistics, a Statistics for Logistics Managers I research team wrote two reports on the Wild Card Scheduling system. The data available to the team came from the 774th Tactical Airlift Squadron (TAS) located at Dyess AFB, Texas. Data were collected from the January through

March, 1979 time-frame. The scheduling system employed at this MAC tactical squadron is very similar to the system used by strategic units in MAC for which data were not available. In their first report, the team examined whether or not the pilots in the 774th TAS have reliable schedules. The team concluded that while the number of duty days and non-duty days were consistent with the schedule, the actual days of duty could not be reliably forecast (6:5-7). In the second report, the team utilized hypothesis testing to examine whether or not the Wild Card Scheduling system created increasing levels of stability over a three-month period from the wild card month to the buffer month to the firm month. The testing proved inconclusive. Using an error probability of 5% (an error rate consistent with other social sciences error rates), the team concluded that there was no more stability in the wild card month than in the buffer month and no more stability in the firm month than in the buffer month. However, increased stability was verified when the firm month was compared to the wild card month (the two extremes) (7:7-8).

SUMMARY

In the preceding chapter, the reader has been presented with background material for the problem of aircrew scheduling for strategic airlift aircrews. The overriding factor in this problem is the uniqueness of the MAC mission in that it does not change drastically in a shift from peacetime to wartime. Instability is ever-present and is a major cause for the current retention problem in MAC. There have been several attempts to solve the problem of the unstable schedule. All of these approaches have met with limited success, at best. A new approach to MAC aircrew scheduling is needed in the very near future or today's problem with retention could be trivial compared to what the future could hold.

CHAPTER III

METHODOLOGY

INTRODUCTION

This chapter will address the statistical procedures required to develop techniques for the pilot scheduler at the squadron level to more effectively utilize the pilot resources. This chapter will specify data collection, grouping of data, and statistical testing of data. The ultimate objective of this research is to develop scheduling techniques for fitting a squadron's monthly flying schedule prior to the beginning of the month. If this can be accomplished, the strategic airlift pilot will know what his workload will be for a period of one month at a time. With this knowledge, the pilot will have a more stable schedule and "Work schedule instability" will be lessened as a factor for separation from the service.

BACKGROUND

Each wing in the Military Airlift Command (MAC) publishes a Wing Operations Plan (WOP) on a monthly basis. This plan contains all the firm scheduled missions for a calendar month. The WOP is distributed to the wing's squadrons approximately ten days prior to the beginning of the month for which the plan applies.

There are three categories of missions which will be necessarily eliminated from statistical analysis. These categories consider exceptional circumstances. The main reason that these missions are eliminated is they have no scheduled mission termination date. Since the statistical analysis utilizes scheduled mission length as one variable, missions without a planned mission return date cannot be utilized. The three categories of missions are: contingency operations such as earthquake relief, the Guyana refugee airlift, and Operation Baby Lift from the former Republic of Vietnam; exercise missions such as Team Spirit, Reforger, or Gallant Shield; and Operational Readiness Inspection (ORI) missions. These missions will depart from home station and will be scheduled for return at a later date.

SUPPORTING DATA

If order to systematically schedule people into a monthly flying schedule, two separate sets of data will be collected, grouped, tested, and analyzed. The first task is to determine if the actual missions flown return to home station on time. If it can be shown that the missions do return to home station on time, the scheduled mission length can be used to block out a number of days that the pilot will be away from home. In addition, a linear regression model will be developed using "scheduled mission length" as the independent variable and "actual mission length" as the dependent variable to more precisely predict the maximum time away from home station for each flying mission.

The second task is to determine the actual length of add-on missions. To develop techniques that will preplan a period that pilots will be available for add-on missions, the authors will determine the actual number of days that 90% of all add-on missions are less than or equal to in duration. This number can then be used to block out a time-frame for keeping some pilots available to the squadron in an "on-call" status. Add-on missions are not scheduled at the last minute. Some are set-up as much as two to three <u>weeks</u> in advance. Some are set-up with only two to three <u>days</u> notice. By the time that the "on-call" pilot reaches the time-frame that he would have to be available, he has probably been notified of his mission if, in fact, he will fly during his "on-call" period.

DATA GATHERING

The Military Airlift Command currently has six operational bases for strategic airlift. Four of these bases have only C-141 aircraft. They are: Charleston AFB, South Carolina, and McGuire AFB, New Jersey on the east coast and Norton AFB, California, and McChord AFB, Washington, on the west coast. Dover AFB, Delaware, has only C-5 aircraft and Travis AFB, California, has both C-141 and C-5 aircraft.

The population that the authors will consider is the length, in days and tenths of days, of all firm scheduled missions and add-on missions for the C-5 and C-141. The table on page 43 shows the 24 hour clock divided into tenths of days. Exclusive of this population are the contingency operation missions, exercise missions, and ORI missions that were previously defined.

The individual command post at each base monitors each flying mission of that wing in terms of mission number, date-time group that the mission departed home station, and date-time group that the mission returned to home station. This information is documented on the MAC Form 315. These forms are kept on file at the individual command posts for a period of ninety days, after which they are destroyed. These MAC Form 315s also contain a copy of all Mission Information Supplements (MIS) for each mission. The initial MIS for an add-on mission will contain the entire proposed mission schedule. The proposed mission schedule for each firm scheduled mission is printed on the monthly WOP. Any changes to the schedule will be accomplished by the publishing of a new MIS for the mission affected.

TABLE 6

24 HOUR CLOCK IN TENTHS OF DAYS

24 HOUR CLOCK	TENTHS OF DAYS
0001 - 0112	0.0
0113 - 0336	0.1
0337 - 0600	0.2
0601 - 0824	0.3
0825 - 1048	0.4
1049 - 1312	0.5
1313 - 1536	0.6
1537 - 1800	0.7
1801 - 2024	0.8
2025 - 2248	0.9
2249 - 2400	1.0

DATA GROUPING AND TESTING

The data for this analysis will come from the command posts at Travis AFB, California, and Charleston AFB, South Carolina. Once the raw data are received, the MAC Form 315s will be matched against the WOP of the corresponding wing to insure that contingency operation missions, exercise missions, and ORI missions are removed from consideration. The MAC Form 315s will then be separated into four groups of data. These groups will be formed for the purposes of testing and analysis. The four groups are:

Group 1 - C-141 missions from Travis AFB
Group 2 - C-141 missions from Charleston AFB
Group 3 - C-141 missions from Travis AFB and Charleston AFB
Group 4 - C-5 missions from Travis AFB

From each group of actual missions flown, a simple random sample will be extracted. A sample population of differences will result from comparing the actual mission length to the scheduled mission length. Each sample population of differences will be tested for normality using the Kolmogorov-Smirnov (K-S) Goodness of Fit Test. If it is concluded that the population of differences is normally distributed, the T-Test will be conducted to make inferences about the population mean of differences from matched samples. If it is concluded that the population of differences is not normally distributed, the Sign Test will be used to make inferences about the population median of differences from matched samples.

After these tests have been completed, the data will be regrouped and reclassified. The subsequent grouping of the data will contain only add-on missions. These missions will be classified into the following three groups:

Group 5 - C-141 add-on missions from Travis AFB

Group 6 - C-141 add-on missions from Charleston AFB

Group 7 - C-5 add-on missions from Travis AFB

From each group of add-on missions flown, a sample of scheduled mission lengths will be taken. From these samples, inferences about the populations will be made. Using the sample mean and variance as unbiased estimators of the population mean and variance, the 90th percentile of each population of add-on missions will be estimated. From this estimate, a 95% upper confidence interval bound will be determined. Thus, the authors will be able to conclude with 95% confidence that 90% of the add-on missions flown from a given population are less than or equal to the upper confidence interval bound for that population.

As an example, suppose that a random sample of 30 add-on missions is extracted from Group 5. From this sample, the mean is determined to be 4.0 days, the sample variance is 1.0 days. Based upon the cumulative probability of the standard normal distribution, the 90th percentile is 1.282 standard deviations away from the mean. Therefore, the estimate for the 90th percentile for Group 5 would be 5.282 (4.0 + 1.282) days.

To develop a 95% upper confidence interval bound, the estimated standard error of the mean is used. This error is the sample variance divided by the square root of the sample size. For this example, the estimated standard error of the mean is $1/(30)^{\frac{1}{2}}$, or 0.1826 days. For a 95% upper confidence interval bound, the cumulative probability of the standard normal distribution is 1.645 standard deviations. Therefore, the 95% upper confidence interval bound is 5.5824 (5.282 + (1.645 X 0.1826)) days. Thus, the conclusion would be that 90% of all add-on missions from Group 5 are less than or equal to 5.5824 days in length. The 95% upper confidence interval bound will be used to section off a series of days for a pilot to be on "alert" for add-on missions.

Finally, the relationship between the independent variable (scheduled mission length) and the dependent variable (actual mission length) will be further examined through the development of a linear regression model. The proposed model is of the form:

$$Y = \beta_0 + \beta_1 X$$

where Y = the actual length of the mission

X = the scheduled length of the mission

β_0 = a parameter indicating the Y intercept

β_1 = a parameter indicating the slope of the regression line

Regression analysis will be accomplished on the C-141 and C-5 data independently.

SCHEDULING CRITERIA

The techniques developed in this thesis are constrained by several criteria. Criteria 1 through 4 are considered to be givens in a typical MAC squadron. Criteria 5 through 10 are based on the authors' best estimations of a true situation. Each squadron will probably operate under slightly different criteria. Some criteria may change on a month-to-month basis in a squadron.

CRITERIA

1. There are 18 aircraft assigned to each squadron.
2. The authorized aircrew ratio is 2.0 per aircraft.
3. Two pilots are required per aircraft, the aircraft commander and the co-pilot.
4. Based on the above three criteria, 72 line pilots

are authorized per squadron, 36 aircraft commanders and 36 co-pilots.

5. An average month consists of 21 working days, flying and alert, and 9 days of scheduled free time, including crew rest.

6. Personnel who have additional duties within the squadron work two consecutive weeks on duty and four consecutive weeks off duty. Their off duty time is used for flying, alert, and scheduled free time.

7. The following positions are required to be manned at all times and the resources must come from the line assigned pilots:

    a. Current Operations (squadron level) - one aircraft commander

    b. Pilot Scheduler - one aircraft commander and one co-pilot

    c. Security/Safety - one aircraft commander

    d. OER Monitor - one pilot

    e. Awards/Decorations - one pilot

8. One aircraft commander and one co-pilot will be DNIF (Duty Not to Include Flying).

9. A maximum of three pilots from each crew position will be on leave at any one time.

10. The squadron commander, operations officer, chief pilot, and executive officer are not included in

the 72 pilots in the squadron. Normally, these pilots are not part of a crew. They are observer crew members on a mission. They may fly the aircraft, but they are not paired with a single co-pilot to fly a full mission.

Based on the above criteria and the previous test results, scheduling techniques will be developed to fit the flying demand. Pilots will be scheduled according to the scheduled mission length of the firm scheduled missions and a pool of pilots will be on alert for a block of days to be used on add-on missions.

CHAPTER IV

DATA TESTING AND ANALYSIS

INTRODUCTION

This chapter will detail the statistical tests conducted by the authors to attempt to verify the research questions proposed at the end of Chapter I. In order to reacquaint the reader with these questions, their repetition follows:

1. Do off station missions return to home station when they are scheduled?
2. Can the length of time away from home station be reliably scheduled for add-on missions prior to mission set-up?
3. Is there a direct statistical relationship between scheduled mission length and actual mission length?

STATISTICAL TESTING

Statistical testing is not an exact science. To illustrate, consider the following explanation of a set of statistical hypotheses. Throughout this chapter, the reader will be presented with several sets of hypotheses of the general form:

H_0: something will happen

H_1: something will not happen

alpha = .05

The key to the test is the H_0. The objective of the test is to either reject H_0 or to fail to reject H_0. Notice that the acceptance of H_0 is not an alternative. If a test is performed and H_0 is rejected, then "something will not happen" is the alternative to be selected. If a test is performed and H_0 is not rejected, then "something will happen" is the alternative to be selected. The fact that H_0 is not rejected does not provide proof in itself of the validity of H_0. It merely means that there is not enough statistical evidence available to reject H_0 (12:268).

The decision to reject or fail to reject H_0 is based on probabilities and not on certainty. Hence, there are chances of error in making a decision. The value of alpha (α) indicates the importance that is attached to the consequences associated with rejecting H_0 when, in fact, H_0 should not have been rejected. In the example, an alpha level of .05 means that the authors are willing to accept a five percent chance of being wrong when H_0 is rejected. This level of error acceptance is commonly adopted in research for the social sciences (11:259, 266).

RESEARCH QUESTION #1

Do off station missions return to home station when they are scheduled?

Since strategic airlift has two primary components, the C-141 and the C-5, this research question will be applied independently to each aircraft. Although the two aircraft face many similar situations, the operation and management of each weapon system is significantly different to warrant separate statistical testing and analysis.

C-141

In order to determine if the C-141 returns to home station on time, the relationship between the two variables, scheduled mission length and actual mission length, must be analyzed. This analysis is accomplished through the vehicle of the Matched Sample T-Test. One assumption of this test is that the population of differences for matched samples is normally distributed or does not depart too markedly from the normal (11:320). An appropriate method to test for normality is the Kolmogorov-Smirnov (K-S) Goodness of Fit Test on a simple random sample of C-141 data received from the Travis AFB and Charleston AFB command posts. The MAC Form 315s were separated by base to yield 117 C-141 forms from Travis AFB and 104 C-141 forms from Charleston AFB. The extracted data is exhibited in Appendix A.

A sample size of ten was selected from each group of forms. The samples from each group were chosen through the use of the Table of Random Digits (11:707). Each MAC Form 315 from Travis AFB received a consecutive number from 001 to 117. Since the Table of Random Digits utilizes five digit numbers, the <u>first</u> three digits of these numbers were used for selection purposes. The Table of Random Digits was entered at the top left hand corner and the authors progressed through table from left to right by rows. If a random number had its first three digits correspond to a MAC Form 315 (001 to 117), that form was extracted for the normality test. Forms were selected without replacement to insure that no mission was selected more than once for the test.

Selection of ten sample missions for Charleston AFB was accomplished in the same manner. This group of MAC Form 315s was numbered 001 to 104. The same Table of Random Digits was utilized, but in this instance, the <u>last</u> three digits were used for selection. Additionally, although the table was entered at the same place, the authors chose to proceed through the table by columns from left to right. Again, there was no replacement. Appendix B exhibits the sampled data. The combined data will be used for an overall test of the normality of the C-141 data.

K-S TEST

There are two assumptions for the K-S Test: the population is continuous and the extracted sample is a simple random sample (11:403). The Statistical Package for the Social Sciences (SPSS) program package for K-S Tests within the CREATE system at the Air Force Institute of Technology School of Systems and Logistics was utilized. Each sample was tested using the K-S Test in SPSS (Travis AFB, Charleston AFB, and Combined). In each case, the hypotheses and the alpha risk are the same:

H_0: the probability distribution is normal

H_1: the probability distribution is not normal

alpha = .05

In each case, the probability distribution under hypothesis is the population of differences from the matched samples. The population of differences is defined as:

$$D_{ij} = Y_{ij} - X_{ij}$$

where Y_{ij} = the ith actual mission length from population j

and X_{ij} = the ith scheduled mission length from population j

The results of each test are shown in Appendix C. The probability value (2-tailed P) on each computer printout was used to determine conclusions. The following rule for two-tailed tests applies: If the computed probability value is less than the stated alpha risk, reject H_0; if not, fail to reject H_0 (12:268).

In each case, the probability value computed is greater than the alpha risk, hence, fail to reject H_0. It is thus assumed that the population of differences is normally distributed due to the lack of evidence against it not being normal. The probability values for the K-S Test are:

Travis AFB = .616

Charleston AFB = .543

Combined = .070

T-TEST

Since the population can now be considered normal. the Matched Sample T-Test package of SPSS for making inferences about the differences between population means will be used. From this, a determination will be made as to whether or not C-141 missions return to home station on time. The following equation and definitions apply:

$$U_D = U_2 - U_1$$

where U_D = the mean of the population of differences

U_2 = the mean of the population of actual mission lengths

and U_1 = the mean of the population of scheduled mission lengths

The hypotheses and the alpha risk are:

$$H_0: \; U_D = 0$$
$$H_1: \; U_D \neq 0$$
$$\text{alpha} = .05$$

As with the K-S Test, this T-Test hypothesis was conducted on each sample. If the computed probability value is less than the stated alpha risk, reject H_0; otherwise, fail to reject H_0.

The results of the T-Test are shown in Appendix D. In each instance, the probability value computed is greater than the alpha risk. The computed probability values are:

Travis AFB = .289
Charleston AFB = .244
Combined = .326

Thus, it is concluded that the mean of the population of differences is equal to zero in each case due to the lack of evidence against it not being so. Alternatively stated, this is to say that there is not enough statistical significance between scheduled mission length and actual mission length to support the alternative hypothesis that C-141 missions do not return to home station on time. Hence, the authors conclude that C-141 missions from Travis AFB, California, and Charleston AFB, South Carolina, <u>do</u> return to home station as scheduled.

C-5

Statistical testing for C-5 missions was accomplished in a manner similar to the testing for C-141 missions. First, a simple random sample was extracted from the 71 MAC Form 315s that were received from the Travis AFB command post. These forms were numbered 01 to 71. The extracted data is exhibited in Appendix A. As with the C-141 tests, the Table of Random Digits was used to select a sample of ten forms. In this particular treatment, the authors used the last two digits of the random number to correspond to the MAC Form 315 to be included in the sample. The table was entered at the bottom right hand corner and the authors proceeded up from right to left by columns, extracting numbers which had their last two digits from 01 to 71. As before, this was done without replacement. The simple random sample for C-5 missions is shown in Appendix B.

K-S TEST

As in the C-141 test, the K-S Test for normality was conducted using the sample population of differences. The hypotheses and the alpha risk are:

H_0: the probability distribution is normal

H_1: the probability distribution is not normal

alpha = .05

As in the C-141 test, the probability distribution under hypothesis is the population of differences between scheduled mission length and actual mission length. The authors used the probability value rule to draw conclusions. The computer output for this K-S Test is shown in Appendix C. The computed probability value is .767. Again, the authors fail to reject H_0, the probability distribution is normal, due to the lack of evidence against this hypothesis.

T-TEST

In this treatment, a T-Test was accomplished on the sample data. This information will be used to determine if the C-5 missions from Travis AFB return to home station on time. As before, the hypotheses and the alpha risk are:

$$H_0: \; U_D = 0$$
$$H_1: \; U_D \neq 0$$
$$\text{alpha} = .05$$

As can be seen in the computer output shown in Appendix D, the computed probability value for the T-Test is .045. This is less than the stated alpha risk and leads the authors to reject H_0. Thus, the conclusion is drawn that the mean of the population of differences for C-5s is not equal to zero, and therefore, they do not return to home station on time.

Although the research question of return reliability for the C-5 has been answered, as a courtesy to the reader, the authors will go one step further to determine if C-5s return early or late. A further analysis of the same T-Test under a different set of hypotheses will yield the answer. The new hypotheses and alpha risk are:

$$H_0: \; U_D \geq 0$$
$$H_1: \; U_D < 0$$
$$\text{alpha} = .05$$

where $U_D = U_1 - U_2$

U_1 = the mean of the population of scheduled mission lengths

and U_2 = the mean of the population of actual mission lengths

It must be stated here that a lower tail test ($U_D < 0$) is required due to the technical way in which the data was entered into the computer program. In addition, it must be understood that if the mean of the population of differences is less than zero, the missions return late.

The probability rule to follow for a one tail test is to take half of the two tailed probability shown on the computer output and compare that value against the stated alpha risk (12:271). As before, if this probability is less than the stated alpha risk, reject H_0. In this case, one half of .045 is .0225 which is less than the alpha risk of .05, requiring the rejection of H_0. Thus, the conclusion is drawn that the mean of the population of differences is less than zero and that C-5 missions from Travis AFB return late.

RESEARCH QUESTION #2

Can the length of time away from home station be reliably scheduled for add-on missions prior to mission set-up?

This research question must be answered for each base on an individual basis due to the fact that there is a difference in the type of cargo and personnel handled and there is a difference in the distance to forward staging locations for missions operating from the east and west coasts. Most major destinations for aircraft from the east coast require only one or two days to reach, while many west coast destinations require three or four days to reach. If a mission has any urgent or emergency requirements, any of these planning factors could be reduced radically, but most add-on missions do not fit the category of urgent or emergency mission.

The authors will only address C-141 missions. C-5 missions will not be considered due to the results obtained in the previous section. Basically, C-141 missions operate on a reliable flow time and C-5 missions do not.

TRAVIS AFB

Of the 117 MAC Form 315s received from Travis AFB, 35 of them represented add-on missions. The scheduled mission length of each of these 35 add-on missions was used to create a sample for testing purposes. This is not a random sample of all add-on missions from Travis AFB since it encompasses all pertinent add-on missions during the data collection period.

It is also useful to note that the three month period from which data was gathered did not appear to be an aberration from the normal amount of add-on missions. Travis AFB was not involved in an ORI, nor was the base either over-committed or under-committed to deployment exercises which would have created an abnormal situation. The authors judged that the period studied was about average for the number of add-on missions and the type of add-on missions flown.

This sample of add-on missions was tested for normality using the K-S Goodness of Fit Test program package in SPSS. The hypotheses and the alpha risk are as follows:

H_0: the probability distribution is normal

H_1: the probability distribution is not normal

alpha = .05

The authors used the probability value rule to draw conclusions. From the computer output shown in Appendix E, the computed probability value is .722. This leads to the non-rejection of H_0. Also, it can be seen from the computer output that the mean of the sample is 3.9514 days with a standard deviation of 2.4977 days. The standard normal distribution prescribes that the 90th percentile is 1.282 standard deviations away from the mean. Applying this information to the sample of C-141 add-on missions from Travis AFB, the authors conclude that the 90th percentile of this sample is equal to 7.1535 (3.9514 + (1.282 X 2.4977)) days. It is important to note that the 95% confidence interval need not be developed because the sample contains all the data.

The figure of 7.1535 days for Travis AFB add-on missions can be very useful to the squadron's pilot scheduler. The data was collected for the August to October of 1979 time-frame. This data would be useful in assembling the December schedule. (November would be used for data collection, data analysis, and preparation of December's schedule.) The pilot scheduler would use moving average theory to predict the approximate number of add-on missions and the length of those missions. As an example, the reader may refer to the tables on pages 63 and 64.

CHARLESTON AFB

Inspection of the data for Charleston AFB add-on missions leads the authors to suspect that these add-on mis-

TABLE 7

MOVING AVERAGE FOR THE

NUMBER OF ADD-ON MISSIONS

MONTH	NUMBER OF ADD-ON MISSIONS	MOVING AVERAGE	MONTH USED FOR
January	30	?	March
February	28	?	April
March	35	31.0*	May
April	18	27.0	June
May	27	26.7	July
June	31	25.3	August
July	30	29.3	September
August	34	31.7	October
September	22	28.7	November
October	28	28.0	December
November	30	26.7	January
December	31	29.7	February

* - 31.0 is the average of January (30), February (28), and March (35). This average would be compiled in April for use in assembling May's schedule.

TABLE 8

MOVING AVERAGE FOR THE

LENGTH OF ADD-ON MISSIONS

MONTH	LENGTH OF ADD-ON MISSIONS	MOVING AVERAGE	MONTH USED FOR
January	7.24	?	March
February	7.16	?	April
March	7.08	7.160*	May
April	7.31	7.183	June
May	6.98	7.123	July
June	6.84	7.043	August
July	7.06	6.960	September
August	6.89	6.930	October
September	7.27	7.073	November
October	7.11	7.090	December
November	7.45	7.277	January
December	6.98	7.150	February

* - 7.160 is the average of January (7.24), February (7.16), and March (7.08). This average would be compiled in April for use in assembling May's schedule.

sions are relatively shorter in actual mission length than those from Travis AFB. The reason for this is that the majority of the Charleston AFB add-on missions are designed to either transport army troops around the east coast on a one-day mission or airlift cargo to Europe and quickly return to home station.

Of the data received from the Charleston AFB command post, 47 missions were of the add-on type. These were grouped and tested in the same manner as were those from Travis AFB. The K-S Test for normality was performed using the same hypotheses and alpha risk. The computer output for this test is shown in Appendix E. The output yields a probability value for normality of .011 which is well below the stated alpha risk of .05. This leads to the rejection of H_0, hence, the authors conclude that the distribution is not normal.

A closer examination of the actual data reveals that many of the add-on missions from Charleston AFB are scheduled (as suspected) for one day or less. This fact would account for the failure of the test. Since the data is highly skewed, the authors will examine the data again. In this treatment, they will classify and interpret the data empirically.

The 47 add-on missions were categorized by scheduled mission length. The categorized form of the data appears in the table on page 66.

TABLE 9

CHARLESTON AFB

ADD-ON MISSIONS

CATEGORY	MISSION LENGTH	# MISSIONS
I	0.0 - 1.0 days	20
II	1.1 - 2.0 days	15
III	2.1 - 3.0 days	5
IV	3.1 - 4.0 days	2
V	4.1 - 5.0 days	2
VI	5.1 - 6.0 days	2
VII	6.1 - Highest	1

Ninety percent of these 47 missions equates to exactly 42.3 missions. As Table 9 indicates, 42 of these missions are scheduled for 4.0 days or less. This information is just as useful to the pilot scheduler at Charleston AFB as the more formal statistical information was to the pilot scheduler at Travis AFB. Whereas 90% of Travis AFB add-on missions are just over seven days, 90% of Charleston AFB add-on missions are just over four days.

RESEARCH QUESTION #3

Is there a direct statistical relationship between scheduled mission length and actual mission length?

Although it has been established that C-141 missions return to home station on time for the groups and periods studied, it has not been determined whether or not there is any direct correlation between scheduled mission length and actual mission length. This research question is designed to inform the squadron's pilot scheduler of a more precise time estimate of when a given mission will return. Using past mission data, the scheduler may be able to predict actual mission length when the scheduled mission length is known. One simple technique for this prediction process is that of regression analysis.

The authors will test to see if a simple linear regression function can be applied to fit data for the C-141. Since the C-5 return reliability is not acceptable, it is already suspected that a C-5 regression function would not be a strong tool of mission length prediction.

C-141 REGRESSION ANALYSIS

Due to the limited amount of data received and the results of the combined T-Tests performed on the data, one simple linear regression function will be developed using all of the available C-141 data. The general regression function is of the form:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$$

where Y_i = the actual mission length of the ith observation

X_i = the scheduled mission length of the ith observation

β_0 = parameter representing the Y intercept of the regression function

β_1 = parameter representing the slope of the regression function

ε_i = the random scatter component that is independent and normally distributed with a mean of zero and a constant variance at all levels of X

$i = 1, 2, \ldots, n$ (11:439)

If it is determined that there is a significant relationship between the independent variable (scheduled mission length) and the dependent variable (actual mission length) and that the regression function is apt, then this simple linear regression model can be used to predict values for the actual mission length of future missions given the scheduled mission length. This would be of immense help to the squadron's pilot scheduler in the assembly of the pilots' monthly schedule.

The results of the SPSS regression analysis program for C-141's are shown in Appendix F. The coefficient of determination is .67283. This indicates that the variability in actual mission length is reduced 67.283% when the scheduled mission length is considered (11:457). Also noteworthy is the coefficient of simple correlation which is .82026. This is a descriptive measure of the degree of linear relationship that exists between the X and Y variables. The closer that this value is to 1.0, the greater is the degree of linear statistical relationship in the sample observations (11:458).

Testing of the validity of the statistical relationship for this regression model was accomplished by determining the aptness of the model. Two useful methods to employ in this regard are examinations of the scattergram and the standardized residual plot. By observation of the scattergram (Appendix F), it can be seen that the data points tend to scatter at random about a fitted straight line. This indicates that the regression function is linear (11:481).

By observation of the standardized residual plot, it is seen that the residuals tend to scatter at random about the zero line. Additionally, it appears that the variance is fairly constant. These facts are deemed to be convincing evidence to the authors that the regression function under consideration is apt. Futhermore, the residuals were examined for normality through the use of the standardized residuals. A standardized residual is a residual that has been divided by the estimated standard deviation ($\sqrt{(MSE)}$). If the model is apt, the standardized residuals should tend to follow the standard normal distribution when the sample size is large (11:483).

In this case, the Mean Square Error (MSE) is 3.1622 and the square root of the MSE is 1.7783. A comparison of the $\sqrt{(MSE)}$ to the residuals indicates how many of the standardized residuals fall within one standard deviation and two standard deviations of the mean. If the magnitude of the residual is less than or equal to the $\sqrt{(MSE)}$, the standardized residual is within one standard deviation. Also, if the magnitude of the residual is less than or equal to $2\sqrt{(MSE)}$, the standardized residual is within two standard deviations of the mean (11:483).

Information is also needed as to how many of the standardized residuals are positive and how many are negative. From the standardized residual plot, it is observed that more are negative than positive, but not significantly so.

Also, most of the standardized residuals lie within one standard deviation and nearly all of them lie within two standard deviations of the mean. This evidence supports the contention that the standardized residuals tend to follow the standard normal distributions. It is thus concluded that the distribution of the residuals is normal, therefore, the distributions of Y are normal with constant variance and the linear regression function is apt (11:483).

The next appropriate step is to determine whether or not a relationship exists between the X and Y variables. The test will use the following hypotheses and alpha risk:

$$H_0: \quad \beta_1 = 0$$
$$H_1: \quad \beta_1 \neq 0$$
$$\text{alpha} = .05$$

This test uses the F* statistic shown on the computer output. The decision rule to follow is:

$$\text{If } F^* \leq F(1 - \alpha;\ 1,\ n - 2)\text{, conclude } H_0$$
$$\text{If } F^* > F(1 - \alpha;\ 1,\ n - 2)\text{, conclude } H_1$$

SOURCE: (11:479-480)

The computed F* statistic is 450.37752. From the statistics tables, the value of F(.95; 1, 219) is extracted. (219 is the result of the addition of the total of the C-141 observations [117 + 104] minus 2.) The exact value is not available, but since F(.95; 1, 120) is equal to 3.92, and

F(.95; 1, inf.) is equal to 3.84, the F value that is sought lies between 3.84 and 3.92 (11:696). The true value is unimportant due to the extremely high value of F*. The conclusion that is drawn is H_1, that $\beta_1 \neq 0$. Thus, it can be stated with 95% confidence that there is a statistical relationship between the scheduled mission length and the actual mission length.

Once this relationship has been established, the general regression formula can be reformatted to read:

$$\hat{Y}_h = \beta_0 + \beta_1 X_h$$

$$\text{therefore, } \hat{Y}_h = .3187225 + .9936839X_h$$

The point estimator of the expected value, $E(Y_h)$, of Y is $\hat{Y}_h$, where $\hat{Y}_h$ is the value of the estimated regression function when $X = X_h$ (11:448). The above equation is important because the objective is to use this regression function to predict the actual mission length with a given level of confidence. Due to the fact that only the point estimators of β_0 and β_1 are known, the prediction limits consider the following two sources of variation:

1. Variation in the possible location of the distribution of Y.
2. Variation within the probability distribution of Y.

SOURCE: (11:471)

The conclusion drawn is that the prediction interval developed for an individual response is wider than the confidence interval for the mean response, given the same level of confidence. The two sided prediction interval for Y_h with a confidence coefficient of $1 - \alpha$ is of the form:

$$L = Y_h - t(1 - \alpha/2; n - 2)\, s(d_h)$$
$$U = Y_h + t(1 - \alpha/2; n - 2)\, s(d_h)$$

$$\text{where, } s(d_h) = \sqrt{MSE \left[1 + 1/n + \frac{(X_h - \bar{X})^2}{\Sigma (X_i - \bar{X})^2} \right]}$$

SOURCE: (11:471-472)

Given the established regression formula on page 72, the prediction interval shown above, and any level of X (scheduled mission length); the expected time away from home station can be calculated along with the high and low values of the interval for any confidence level. This will allow the squadron's pilot scheduler to use personnel judgment along with the aforementioned statistical procedures to fully complete the monthly flying schedule prior to the start of the month.

C-5 REGRESSION ANALYSIS

The data collected for C-5 missions from Travis AFB was used to analyze the same linear regression function as previously mentioned. The computer output for this data is contained in Appendix G. In the case of the C-5, the coefficient of determination is a low .37916. This is an indication of greater variability in the C-5 mission return time than for the C-141. Also, the scattergram shows that the data points do not tend to follow any linear form. The standardized residual plot shows many more negative values than positive ones. Finally, the variance does not appear to be constant.

These results indicate that the regression function under consideration is probably not apt and it should not be relied upon for the prediction of future mission lengths. The great variability in C-5 mission lengths is shown by examining the means and standard deviations of the X and Y variables. The mean of the independent variable (X) is computed to be 3.3183 days with a standard deviation of 1.1416 days. However, the mean of the dependent variable (Y) is 4.1592 days with a standard deviation of 2.0807 days.

CHAPTER V

RECOMMENDATIONS

INTRODUCTION

This research effort has one objective which, if attained, would provide a more experienced and effective strategic airlift pilot force. If the separation of pilots can be slowed or halted due to positive steps, such as increased scheduling stability, then the strategic airlift pilots will have gained a perceptible measure of control over their own activities. Also, the top level managers of the Air Force would not have to keep sending more and more pilots to Undergraduate Pilot Training just to watch them serve out their initial commitment to the military before separating to join the commercial airlines.

As indicated before, increased scheduling stability is only one of many changes in the Military Airlift Command that should be achieved _if_ the senior leaders truly wish to retain their middle-management force. In the months that the authors have devoted to this thesis, they have come to believe that the senior leadership of the Air Force _is_ genuinely interested in and supportive of increased retention related devices and ideas. If the ideas in this thesis could be put into practical application by dedicated pilot management personnel, the authors strongly believe that pilot retention for the six to eleven year group in MAC can be sharply increased. Also, the impression of a willingness to change policy to adapt to the "needs of the people" by upper level management will be created in the minds of the targeted group.

ANSWERS TO THE RESEARCH QUESTIONS

This thesis has considered three research questions. These questions and there answers will be reviewed.

RESEARCH QUESTION #1

Do off station missions return to home station when they are scheduled?

Using an alpha risk of .05, it was concluded that C-141 missions from both Travis AFB and Charleston AFB did return to home station on time for the period studied. The computed probability value was .289 for Travis AFB and .244 for Charleston AFB (page 56). However, it was concluded that C-5 missions did not return to home station on time. The computed probability value for C-5 missions was .045, lower than the alpha risk of .05. It was further determined that C-5 missions returned late to home station.

RESEARCH QUESTION #2

Can the length of time away from home station be reliably scheduled for add-on missions prior to mission set-up?

First, it was obvious to the authors that each base had different percentages of add-on missions with different average lengths. Second, C-5 add-on missions were not considered in this portion of the analysis since it was concluded in Research Question #1 that C-5 mission return times were not reliable and that C-5s returned late. Third, the lengths of the add-on missions for Travis AFB C-141s were determined to be predictable with a high degree of reliability over the test period. The 35 add-on missions were away from home station for a period of 7.1535 days or less for the 90th percentile, as determined by the statistical procedures on page 62. The pilot scheduler at Travis AFB could use this figure to preplan add-on missions for December. Finally, the 47 add-on missions for Charleston AFB failed the normality test and the statistical procedures were not useable. However, the authors compiled the table on page 66 and were able to conclude empirically that just under 90% of the add-on missions for Charleston AFB were less than or equal to 4.0 days. Therefore, these add-on missions could also be reliably scheduled.

RESEARCH QUESTION #3

Is there a direct statistical relationship between scheduled mission length and actual mission length?

There is a strong relationship between scheduled mission length and actual mission length for C-141s. The coefficient of simple correlation is over 82%, a very strong indication (page 69). The authors determined the regression formula for all C-141s (page 72). Of course, any individual mission may not fit this formula, but the 221 (117 from Travis AFB and 104 from Charleston AFB) missions that were considered indicate that the use of this regression formula by the pilot scheduler in December would be a great aid.

As suspected, there was not a strong relationship between scheduled mission length and actual mission length for C-5 missions. The width of one standard deviation for the scheduled mission length ranged from 2.1767 to 4.4599 days with a mean of 3.3183 days. The width of one standard deviation for the actual mission length ranged from 2.0785 to 6.2799 days with a mean of 4.1592 days (page 74). The authors consider this relationship not significant enough to warrant further analysis.

RESULTS OF ALL QUESTIONS

In summation, any attempt to stabilize the C-5 schedule through the use of the techniques detailed in this thesis have been discarded by the authors from further consideration. The C-5 schedule can possibly be stabilized, but not through the tools employed in this research alone. On the other hand, the techniques presented in this research are deemed appropriate for the C-141 schedule and the authors will present detailed recommendations for the use of the scheduling techniques in assembling a C-141 squadron's pilot schedule to increase the schedule's stability.

THE SCHEDULING PROCESS

Thus far, the authors have satisfied themselves and, hopefully, the reader in the notion that increased scheduling stability can be achieved through the use of statistical techniques, as previously demonstrated. Yet, it is still necessary to detail how these techniques should be used at the wing and squadron levels to better employ the squadron's pilot resources.

PRELIMINARY STATISTICAL PREPARATION

At the wing level, the Current Operations personnel should maintain a record of all statistical information on firm scheduled missions, add-on missions, and the combination of the two. The only necessary information needed from an outside source are the take-off date-time group from home station and the landing date-time group for return to home station. These times are on the MAC Form

315s and can be received on a daily, weekly, or monthly basis from the wing's command post. As a reminder, the Current Operations personnel should be sure to discard any mission which departed from home station without a scheduled return time.

There are several pieces of information which the Current Operations personnel will need to record: actual mission length, scheduled mission length, and whether or not the mission was an add-on mission. For an example of this data tabulation, see Appendix A.

After every mission for a calendar month has been completed, the Current Operations personnel will select a simple random sample of all the missions in the data base. A method of selection was described in depth on page 53. The results for this example are tabulated in Appendix B. This sample should be tested for normality through the use of a test similar to the K-S Goodness of Fit Test. If the sample passes the normality test, it should then be tested through the use of a device similar to the T-Test to determine if the wing's C-141 missions return to home station on time in a statistical sense. The specific tests mentioned are discussed at length on pages 53-56.

If the C-141 missions pass these tests, the add-on missions should be segregated and the normality test should be performed on these missions separately. After the add-on mission lengths have been determined to be normal, it is

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necessary to compute the mean days and the standard deviation days. If the desired planning factor is the 90th percentile, then the standard deviation of add-on mission days should be multiplied by 1.282 and the resultant figure should be added to the mean days to obtain the number of days that 90% of the add-on missions returned to home station. The example data and computations for this test is on page 62.

If the normality test fails, the add-on mission lengths could be categorized in a manner similar to Table 9 for empirical study. If the 90th percentile (or any other desired planning factor) is deemed reasonable by the wing's key personnel, then use that figure.

Finally, a simple linear regression analysis should be accomplished on the relationship between the scheduled mission length and the actual mission length. These are the X and Y variables, respectively. If a sufficiently high coefficient of simple correlation is achieved (the judgment of the wing's key personnel is needed here), and the other tests for aptness of the model are satisfactory, then a regression function can be structured.

The authors suggest that the data base encompass a three month period of time. This should limit the effects of any abnormal month. All data should be saved and used in a moving average format similar to that exhibited on pages 63 and 64, especially for add-on mission statistics.

Furthermore, the data could be graphed or charted and then studied for trends. Past data should be available from the wing's command post so that implementation of these techniques do not require three months of data preparation before implementation could occur.

SQUADRON PILOT SCHEDULING

Once the Current Operations section has completed the statistical analysis, they should let the squadron's pilot scheduler know three pieces of information:

1. The regression formula, formatted as on page 72.
2. The 90th percentile of add-on mission lengths or whatever percentile is deemed acceptable (from pages 61-66).
3. The expected number of add-on missions for the monthly schedule being compiled (from page 63). Note: If the Current Operation personnel suspect that an abnormal number (high or low) of add-on missions will be required for that month, they should communicate this fact to the squadron. Also, the wing may wish to use a certain percentage of extra missions as a pad for the occurrence of more add-on missions than expected. It is better for the squadron's pilot if they are taken off the schedule at the last minute due to no requirement than to have to leave on an unexpected mission

at the last minute, or to have the squadron have to turn down a mission due to lack of pilots in a position to take an add-on mission. This planning factor should not be too excessive, perhaps 10% of the monthly total.

These items of information should be sent to the squadron along with the monthly WOP.

The next series of steps is crucial to the success of these techniques. The following procedure requires a maximum effort on the part of the pilot scheduler, but after this task is completed, very little effort should be required as the month proceeds.

As a preliminary action, the pilot scheduler should determine which pilots are available to the squadron for which periods in the upcoming month. In order to do this, inquiries should be made to the following groups of pilots:

1. The pilots attached to the squadron for flying purposes, but who work at the wing or higher level of organization.
2. The squadron commander, operations officer, chief pilot and any other pilot who may or may not be able to fly a full mission as a primary crew member.
3. Squadron pilots who have additional duties such as those described on page 48.

4. Squadron pilots who do not fit into any of the above categories, but who have leave, appointments, or other duty related considerations.

All of the pilots should have individual schedules compiled together on a master calendar. Once each pilot has had his input into the schedule through the manner described above, the monthly WOP should be laid out on a separate calendar. The pilots with the most restrictions (duty related) should be assigned missions first, based on any large blocks of unscheduled days. The individual pilot schedules should then be updated to reflect the WOP missions. All of the calendar examples are in Appendix H.

The scheduler should use the scheduled mission length and the regression formula in determining when a pilot will return. If necessary, crew rest should be included as a pad if there are requirements that a pilot must meet after his return from a mission. If a mission is scheduled to change crews at an enroute stop, the scheduler must consider this fact in his application of the regression formula.

Once the WOP missions are scheduled, the pilot scheduler is left with the expected number of add-on missions, the expected length of add-on missions (to the 90th percentile), and many pilots with large blocks of unscheduled days in their individual schedules. Before the pilot scheduler incorporates this information into the schedule, he should receive information from the Current Operations section as to whether or not any large block of add-on missions are expected during any small time-frame in the upcoming month. If so, this factor should be considered in assigning add-on mission alert days. In either case, the following general guidelines for add-on missions should be followed.

If the squadron has its approximate authorized number of pilots, 36 aircraft commanders and 36 co-pilots (from page 48), then the number of add-on missions should be assigned to those pilots on as equitable a basis as possible. The authors suggest one alert period per pilot per month. However, this is just a general rule and some pilots may have very large blocks of unscheduled days which should be set aside for two and even three alert periods, if necessary. It is important to remember that not every add-on mission alert period will be assigned a mission. Also, pilots with other duties may not be able to allot time for an add-on mission, so these pilots should be scheduled on the WOP missions that more precisely fit their own schedules.

It should be noted here that the term "alert" period that is applied to the proposed MAC pilot scheduling techniques is substantially different from a SAC "alert" status. As stated on page 41, an add-on mission is usually established at least several days prior to mission departure. There is no intended implication on the part of the authors that a MAC pilot would be required to sit by the phone in his home or be in an alert facility waiting to launch an airlift mission. A pilot would merely need to stay in contact with his unit in order to be informed about an add-on mission with as much notice as possible.

The best procedure for assigning alert periods for pilots can be best determined by the squadron or wing. For the purposes of an example here, a three day block will be used. If there are no indications that an unusually large number of add-on missions will be forth-coming during a small section of the month, the add-on alert periods should be applied to the monthly schedule based on the pilot scheduler's best estimation of when add-on missions will occur. It has been the authors' experience that the majority of add-on missions occur in the last two weeks of the month, and the majority of pilots (as an example, two-thirds of the pilots) should be scheduled for a three day add-on mission alert period during the second half of the month. The authors again stress that the judgment of the Current Operations personnel and the pilot scheduler are key to the success of scheduling add-on mission alert periods.

If an add-on mission is assigned to the squadron, there should be at least one aircraft commander and one co-pilot who are in a position to take the mission. The add-on mission should have a scheduled mission length associated with it. This scheduled mission length should be entered into the regression function to predict the most likely actual mission length. It may be the case that one pilot may be able to take a relatively short mission, but not a longer one, and the decision as to which pilot to assign to a mission can be simplified.

Once the alert period ends for a pilot, he should be considered to be off-duty until his next scheduled mission or other duty. The use of alert periods means that only a selected few pilots will be able to fly an add-on mission on any given day. This disposes of the common practice of keeping all extra pilots "on the hook" on a day-to-day basis for each day that they are not in a duty status.

The three day period of alert for add-on missions should be considered as more than just a three day period of time when assigning pilots a specific alert time-frame. If a mission is assigned to the squadron, flying time and crew rest must be programmed into the total period before the pilot's next duty. For example, if a wing's add-on mission length (90th percentile) is computed to be 6.0 days, the scheduler should base his establishment of alert periods on the 3.0 days of alert, the 6.0 days of flying time, and the 2.0 days of authorized crew rest. This is a total of 11.0 days that must be available as a block on a pilot's individual schedule. When a mission is set-up, and the scheduled mission length varies decidedly from 6.0 days, the scheduler should use his judgment as to which pilot should be assigned to a mission.

PRESSURES ON THE SCHEDULE

As with all techniques that are new, there are a myriad of "what if" questions that could be asked. As stated, this is a general scheduling plan for implementation at the squadron level, with assistance from the wing. It requires confidence on the part of the major players in the techniques and good judgment on the part of the squadron's pilot scheduler to react to unique situations, especially when an add-on mission is assigned to the squadron. The "what if" questions should be addressed by the scheduler. Some flexibility on the parts of the scheduler and the pilots are necessary, primarily at the outset of this procedure.

It must be understood that this entire method of scheduling is unlike the others that were detailed in Chapter II. This scheduling procedure is done at the lowest level, the squadron. Decentralization of authority is achieved if the upper levels in the chain-of-command allow the squadron to schedule its people without interference. However, there will undoubtably be pressures on the successful use of the previously mentioned procedure from all levels of the chain-of-command.

Once the schedule is firmed up with all the add-on mission alert periods established, every effort should be made to maintain the schedule. The authors will point to two areas of schedule change which should be avoided.

SQUADRON

Unfortunately, the authors have witnessed many instances in which the flying schedule is changed by the members of a squadron to accommodate their personal life or to fly with certain other crew members. Many times, at least one of the pilots who has had his schedule changed is not notified of the change for a few days and is never made aware of the true reason for the change in his schedule. The authors suggest that the pilots' flying schedule be approved by the squadron commander or his designated representative after the completed schedule has been assembled and prior to the schedule's implementation. Then, only a change coordinated with the squadron commander should be made to the schedule. The squadron commander should be aware of any special circumstances which were considered in the assembly of the schedule so that he can inhibit any changes which may alter the special circumstances.

HIGHER HEADQUARTERS

The squadron's pilot scheduler should keep in close contact with the Current Operations section of the wing in order to keep both units aware of any new add-on missions and the squadron's capability to provide pilots for any flight. If a squadron does not have a pilot available in an alert period, the Current Operations personnel should work with the other squadrons to fill the mission, or perhaps, request that Numbered Air Force level Current Operations personnel assign the mission to another wing. In a true emergency, the mission comes first, but in the absence of an emergency, the maintenance of the schedule should be of primary consideration. Based on 36 aircraft commanders and 36 co-pilots each receiving one add-on mission alert period per month and a three day alert period, there should be at least three pilots of each designation on an average day. This should easily cover all the add-on missions that are assigned to the squadron. The only way that a mission would be even sent back to the wing would be if a large number of unexpected add-on missions were assigned to the same squadron in a very short period of time.

CONCLUSION

If the schedule can be continually subverted by either squadron level or higher headquarters personnel, then nothing will be accomplished in scheduling stability and the retention problem will persist. If necessary, the monthly pilot schedule of each C-141 squadron could be reviewed at the wing level (Current Operations or the Deputy Commander for Operations). This would be done in order to enlist the support of the wing for the maintenance of the schedule. The wing could be assured that the squadron had efficiently utilized its pilot resources and the wing could be made directly aware of the number of pilots available for add-on missions on any given day.

CHAPTER VI

CONCLUSION

The authors of this research have examined the problem, strategic airlift pilot retention; one of the problem's main causes, flying schedule instability; and techniques designed to limit the cause of the problem. The techniques offered can work, but should be tested by an individual wing or squadron in order to discover what specific areas need to be adjusted for the individual squadron and any unique scheduling situations. This testing could be done either in actual conditions or in a simulation by the wing's personnel after the actual month is completed.

More importantly, implementation of these techniques throughout the Military Airlift Command requires commitment on the part of MAC's leadership, not only at the Command level, but throughout the chain-of-command and the staff agencies. Statistics point to totally unacceptable rates of voluntary separation by MAC's pilots. In order to retain the pilots, a price must be paid.

Some people think that the easy answer to retention is increased pay. Pay is a price that would be borne by the United States Congress and ultimately by the American people. For the short term, three to five years, it is extremely unlikely that a pay raise of the magnitude that seems to be required to provide a minimal degree of comparability in total pay and benefits could be forth-coming.

This thesis suggests that a different price be paid. The SAAS designated that an unstable schedule was the main cause of the pilot retention problem. If the techniques detailed in this thesis result in a more stable schedule and increased pilot retention, then the price to be paid would be continual control over a pilot's life by the commanders in a pilot's chain-of-command. The payer would be the leadership who may have to relinquish some of his control to the maintenance of the schedule. It will be the choice of the senior commanders in MAC to determine if the loss of a small amount of control over their pilots is worth the chance to retain many of these same pilots.

The authors have offered a means by which the squadron can better utilize its people on an individual basis. There are no clear-cut paths to increased retention of the strategic airlift pilot. Also, there are many pilots who would separate despite any attempts to improve their chosen career field. However, it is important to retain as many pilots as possible if the Air Force wants to have a highly motivated and quality middle management force in the 1980s.

FINIS

APPENDICES

APPENDIX A

EXTRACTED DATA

APPENDIX A-1

TRAVIS AFB C-141

#	MISSION NUMBER	1 SCHEDULED LENGTH	2 ACTUAL LENGTH	2 - 1 DEVIATION	CODE WOP = 0 ADD = 1
001	PBP Y515	9.6	8.8	- .8	0
002	PJA 5R3	3.8	2.9	- .9	1
003	PBP 5K1	3.7	3.7	0	0
004	PBP 551	4.3	4.3	0	0
005	PJM 1246/04	2.0	2.5	.5	0
006	PJG 5048/X1	1.5	1.4	- .1	1
007	PBP 5K1	3.7	4.5	.8	0
008	PJG 5050/X1	.5	.5	0	1
009	PJG 5049/X1	.5	.5	0	1
010	PBP 5K1	3.7	3.7	0	0
011	PJA 5F3	3.5	7.3	3.8	0
012	PBP Y515	7.0	6.2	- .8	0
013	PJP 575	3.6	6.8	3.2	1
014	PJP 555	.4	.4	0	0
015	PBP 555	4.2	5.7	1.5	0
016	PEN 509	5.2	4.4	- .8	1
017	PJA 5F3	3.6	2.6	-1.0	0
018	PJX J071/BE	1.8	3.5	1.7	0
019	PBP Y515	6.0	5.5	- .5	0
020	PJM 1216/01	5.0	5.1	.1	0
021	PJX A068	2.1	3.1	1.0	0
022	PJX A066/BE	1.3	1.1	- .2	1
023	PBP 551	3.7	4.2	.5	1
024	PJP 555	.4	.4	0	0
025	PBP 555	5.6	6.0	.4	0

026	PBP 527	6.5	14.0	7.5	0
027	PEN 509	1.4	1.4	0	1
028	PEN 505	1.5	1.4	- .1	1
029	PJA 5U3	5.1	5.1	0	0
030	PBP Y515	6.3	8.1	1.8	0
031	PJX A038/BE	4.6	3.3	-1.3	0
032	PEN 509	1.2	1.1	- .1	1
033	PBP 5K1	3.7	3.7	0	0
034	PJM 1165/02	2.5	3.1	.6	1
035	PJM 1702	1.5	1.6	.1	1
036	PEN 505	1.1	1.2	.1	1
037	PJA 5U1	4.9	5.2	.3	0
038	PBP 525	5.6	6.2	.6	0
039	PJG 5012/X3	2.0	1.4	- .6	0
040	PBP Y515	9.6	7.3	-2.3	0
041	PJM 1247/01	4.3	3.9	- .4	1
042	PLP 551	3.3	3.3	0	0
043	PJM 1246/01	5.0	4.1	- .9	0
044	PBP 527	6.4	5.6	- .8	0
045	PJM 2109	5.0	2.6	-2.4	0
046	PJM 1164	2.0	1.3	- .7	1
047	PJM 1165	2.0	2.5	.5	0
048	PJA 5U1	4.9	6.6	1.7	0
049	PJM 1755/01	4.6	4.6	0	1
050	PJX A098/BE	1.8	3.1	1.3	0
051	PJM 4001/87	4.6	4.6	0	1
052	PJP 525	5.6	5.6	0	0
053	PJM 4000/86	4.8	4.2	- .6	1
054	PEN 505/A0	.5	.3	- .2	0
055	PEN 505	.5	.3	- .2	0
056	PBP 515	6.3	6.7	.4	0
057	PBP 555	11.5	2.4	-9.1	0
058	PEN 505	.5	.5	0	0
059	PJP 555	.4	.4	0	0
060	PEN 505A	.5	.2	- .3	0

061	PEN 505B	.5	.2	- .3	0
062	PEN 5L3	6.5	6.3	- .2	1
063	PJG 5045/Y5	3.0	4.6	1.6	0
064	PBP 551	3.5	3.5	0	0
065	PBP 527	6.4	5.2	-1.2	0
066	PEN 505/A0	.5	.4	- .1	0
067	PEN 505/B0	.5	.2	- .3	0
068	PBP Y555	11.9	14.5	2.6	0
069	PJP Y555	.5	.4	- .1	0
070	PJM 1285/01	6.8	7.6	.8	1
071	PJA 5U1	4.9	5.5	.6	0
072	PBP 525	5.6	5.5	- .1	0
073	PJP 555	.5	.4	- .1	0
074	PBP 555	5.7	17.6	11.9	0
075	PEN 505	.5	.4	- .1	0
076	PBP Y515	9.6	8.4	-1.2	0
077	PJM 1172/01	5.0	4.7	- .3	0
078	PJP Y555	.5	1.3	.8	0
079	PBP Y555	11.9	10.6	-1.3	0
080	PJM 1973/02	3.0	3.0	0	1
081	PAM 3911/02	5.8	8.7	2.9	1
082	PJM 1247/15	5.5	6.9	1.4	1
083	PBP Y515	7.0	7.1	.1	0
084	PJM 2885/01	5.0	4.2	- .8	0
085	PBP Y515	7.0	11.8	4.8	0
086	PJA 5F3	3.5	4.6	1.1	0
087	PLP 551	2.0	3.4	1.4	0
088	PJX A144/BE	1.8	3.3	1.5	0
089	PJA 5F3	3.6	2.4	-1.2	0
090	PJX J001/EG	1.5	2.3	.8	1
091	PBP 5K1	3.7	3.7	0	0
092	PBP Y515	6.0	6.0	0	0
093	PJM 1216/05	4.0	4.4	.4	1
094	PEN 509	6.8	7.8	1.0	1

095	PJM	3251/01	3.0	1.1	-1.9	0
096	PBP	527	6.5	14.0	7.5	0
097	PLP	551	2.0	3.6	1.6	0
098	PJX	U006/KA	7.0	7.0	0	0
099	PAM	2892/01	7.0	3.1	-3.9	0
100	PJG	5001/U5	3.0	1.9	-1.1	0
101	PJP	575	3.6	3.7	.1	1
102	PJA	5F3	3.6	1.4	-2.2	0
103	PMX	S808/BE	1.6	1.5	- .1	1
104	PJP	555	.5	.4	- .1	0
105	PBP	555	5.7	9.1	3.4	0
106	PMX	S001/KA	8.5	8.4	- .1	1
107	PAM	3917/03	5.7	8.4	2.7	1
108	PAM	3917/02	5.8	5.9	.1	1
109	PJM	4001/98	2.5	2.2	- .3	1
110	PJM	4001/97	2.5	4.4	1.9	1
111	PJM	4001/96	2.5	2.1	- .4	1
112	PBP	527	6.4	1.6	-4.8	0
113	PJP	Y555	.5	.4	- .1	0
114	PBP	Y555	11.9	11.9	0	0
115	PBP	525	5.6	5.5	- .1	0
116	PAM	3917/01	5.8	5.8	0	1
117	PJA	5U3	5.1	5.4	.3	0

APPENDIX A-2

CHARLESTON AFB C-141

#	MISSION NUMBER	1 SCHEDULED LENGTH	2 ACTUAL LENGTH	2 - 1 DEVIATION	CODE WOP = 0 ADD = 1
001	AJA 483	2.2	3.2	1.0	0
002	AJG 4020/X5	.5	1.4	.9	0
003	AJA 473	1.5	1.6	.1	0
004	AJG 4021/X5	.5	1.3	.8	0
005	ABA 429	1.1	3.2	2.1	0
006	AJG 4033/X8	.7	.6	- .1	1
007	ABA 467	.4	.3	- .1	0
008	AWM 2199	.6	.5	- .1	1
009	AJG 4039/Y3	.5	.5	0	1
010	AJM 2199	.5	1.4	.9	1
011	AJM 1083	.5	.5	0	1
012	AJG 4040/Y3	.5	.4	- .1	1
013	ABA 429	1.1	1.1	0	0
014	AJA 4F3	1.2	1.5	.3	0
015	AJG 4042/Y7	.5	.4	- .1	1
016	AJA 4F3	1.2	1.2	0	0
017	ABA 481	1.5	1.4	- .1	0
018	AJG 4056/Y2	2.3	2.2	- .1	1
019	AJG 4061/W1	2.6	2.3	- .3	1
020	AJG 4052/Y2	.5	.4	- .1	1
021	AEN 405/C	.2	.2	0	0
022	AEN 405/PA	2.3	1.8	- .5	1
023	AJG 4054/Y2	.5	.6	.1	1
024	AJA 471	1.5	2.5	1.0	0
025	AJA 441	4.4	4.2	- .2	0

026	AEN 405	.4	.4	0	0
027	AEN 405/A	.2	.2	0	0
028	ABA 477	.5	.6	.1	0
029	AJA 475	1.5	1.3	- .2	0
030	AJG 4053/Y2	.5	.4	- .1	1
031	AJG 4043/X8	.1	.2	.1	1
032	AJM 2927	1.3	2.2	.9	1
033	AJA 4R3	1.2	1.2	0	0
034	ABA 4P1	1.1	1.1	0	0
035	AEN 405/A	.2	.2	0	1
036	AAM 2972	1.3	1.4	.1	1
037	AEN 409	1.6	1.5	- .1	0
038	AEN 405	.2	.2	0	0
039	AJM 1936/01	.5	.3	- .2	1
040	AJG 4035/U	.4	.3	- .1	1
041	AJM 3253/01	7.2	8.2	1.0	1
042	AJA 483	2.2	2.1	- .1	0
043	AJA 471	1.5	1.5	0	0
044	ABA 429	1.1	1.0	- .1	0
045	AEN 409/A	5.3	5.4	.1	1
046	AJA 4W5	3.8	8.0	4.2	0
047	AJX U013	1.5	2.6	1.1	1
048	AJA 451	3.1	3.3	.2	0
049	AQA Y417	7.8	8.0	.2	0
050	ABA 4F3	1.2	2.3	1.1	0
051	AEN 405/B	.2	.2	0	0
052	AJA 473	1.5	1.3	- .2	0
053	AQA Y417	7.8	7.8	0	0
054	ABA 477	.5	.6	.1	1
055	AJA 483	2.2	2.2	0	0
056	AEN 409	3.7	5.7	2.0	0
057	AJA 4F3	1.2	1.2	0	0
058	AJG 4018	1.5	1.4	- .1	1
059	AJA 441	4.4	14.9	10.5	0

060	ABA 429	1.1	1.9	.8	0
061	AJA 471	1.5	1.5	0	0
062	AJA 451	3.1	5.4	2.3	0
063	AJG 4068	3.5	3.4	- .1	1
064	AJG 4049	4.4	2.4	-2.0	1
065	ABA 431	2.9	3.9	1.0	1
066	AJA 4R3	2.9	4.0	1.1	1
067	AJM 4560	1.4	1.4	0	1
068	AJA 473	1.5	1.6	.1	0
069	AJG 4066/Y2	1.3	1.3	0	1
070	AJG 4067/Y2	1.4	1.3	- .1	1
071	AEN 405	.4	.4	0	0
072	AEN 405/C	.2	.2	0	0
073	AJA 4F3	1.2	1.1	- .1	0
074	ABA 491	4.4	4.3	- .1	0
075	AEN 405/B	.2	.2	0	0
076	AWM 2199	.4	.4	0	0
077	AJM 4552/02	1.2	3.7	2.5	1
078	AJM 4552/01	.5	4.3	3.8	1
079	AMX U016/CD	1.6	1.5	- .1	1
080	AEN 405	.2	.2	0	0
081	AAM 3926/01	1.2	1.4	.2	1
082	AJX U011	5.5	4.1	-1.4	1
083	ABA 479	1.5	1.3	- .2	0
084	AJA 475	1.5	1.5	0	0
085	AJA 4F3	1.2	1.2	0	0
086	AJM 1935/01	.4	.4	0	1
087	AJA 435	3.8	4.8	1.0	0
088	ABA 463	3.6	3.4	- .2	0
089	AJG 4032	4.6	4.4	- .2	1
090	ABA 493	3.4	3.4	0	0
091	AJA 4F3	1.2	1.3	.1	0
092	AJG 4037/Y3	1.2	1.1	- .1	1
093	AJG 4036/Y3	1.2	1.2	0	1

094	AJG	4034/Z5	1.7	1.3	- .4	1
095	ABA	407/X	.2	.1	- .1	1
096	AEN	405/A	.2	.2	0	0
097	AJA	443	4.0	4.8	.8	0
098	AJM	1728	1.3	.6	- .7	1
099	ABA	4P1	1.1	1.0	- .1	0
100	AJM	1762/01	.5	.5	0	1
101	AJA	4F3	1.2	1.2	0	0
102	AJM	1782/03	.4	.4	0	0
103	ABA	473	1.3	1.4	.1	1
104	AJA	4W5	3.8	4.4	.6	0

APPENDIX A-3

TRAVIS AFB C-5

#	MISSION NUMBER	1 SCHEDULED LENGTH	2 ACTUAL LENGTH	2 - 1 DEVIATION	CODE WOP = 0 ADD = 1
01	PJX J003/BE	3.5	3.3	- .2	0
02	PJG 3011/XB	1.4	1.4	0	0
03	PJG 3010/XC	2.2	2.3	.1	0
04	PJM 1257/01	2.9	4.0	1.1	1
05	PJX J004/BE	2.3	2.3	0	0
06	PAM 3690/01	2.4	6.5	4.1	1
07	PJM 2145/01	1.2	1.2	0	1
08	PJG 3055/XC	2.5	2.1	- .4	0
09	PJM 2135/01	1.3	1.2	- .1	1
10	PJM 1218/01	6.5	9.5	3.0	1
11	PJM 2178/01	3.4	5.2	1.8	1
12	PJM 1405/01	3.0	3.1	.1	1
13	PJM 1976/03	1.2	1.2	0	1
14	PJM 1217/01	6.0	5.9	- .1	1
15	PJA 3F1	2.9	4.0	1.1	0
16	PJA 331	2.7	4.2	1.5	0
17	PBP 351	3.7	3.8	.1	0
18	PBP 3K1	3.6	3.7	.1	0
19	PBA 3F1	2.9	3.9	1.0	0
20	PBP 351	4.0	8.6	4.6	1
21	PJP 377	4.7	4.9	.2	0
22	PBP 3R1	3.6	3.6	0	0
23	PBP 3K1	2.6	2.1	- .5	0
24	PJA 331	2.7	3.1	.4	0
25	PJA 3R5	4.7	3.7	-1.0	1

26	PEN 305	1.6	2.1	.5	1
27	PBP 351	3.7	8.9	5.2	0
28	PEN 305	2.3	2.2	- .1	1
29	PBP 3K1	3.6	3.5	- .1	0
30	PBA 3F1	2.9	3.8	.9	0
31	PBP 3C1	4.2	5.8	1.6	1
32	PBP 3K1	2.6	3.1	.5	0
33	PBP 3K1	2.6	3.6	1.0	0
34	PJA 331	3.0	6.0	3.0	0
35	PBP 351	3.6	10.0	6.4	0
36	PJP 375	4.3	4.4	.1	1
37	PEN 305	4.5	4.5	0	1
38	PEN 3R1	3.8	10.8	6.8	0
39	PJP 377	4.7	3.6	-1.1	0
40	PBP 3K1	3.6	3.7	.1	1
41	PJP 377	4.7	4.7	0	0
42	PEN 309	6.8	- .7	1	1
43	PBP 3K1	3.6	5.6	2.0	0
44	PBP 351	3.6	4.2	.6	0
45	PJA 3R5	3.5	3.9	.4	0
46	PBP 371	3.5	3.5	0	1
47	PBP 351	3.7	3.8	.1	0
48	PBP 3R1	3.6	4.8	1.2	0
49	PJA 331	2.8	3.7	.9	0
50	PJA 331	2.7	3.0	.3	0
51	PEN 305	1.5	1.4	- .1	1
52	PBP 351	3.6	3.7	.1	0
53	PEN 305	1.1	1.8	.7	1
54	PEN 305	2.3	2.2	- .1	1
55	PJP 377	4.7	4.7	0	0
56	PBP 3K1	3.6	8.6	5.0	0
57	PBP 351	3.7	3.7	0	0
58	PBP 377	4.7	7.8	3.1	0
59	PJA 3R5	3.5	2.9	- .6	0

60	PBP 351	3.6	3.8	.2	0
61	PBP 3K1	3.6	4.9	1.3	1
62	PEN 305	1.5	1.3	- .2	1
63	PBP 3R1	3.6	2.5	-1.1	0
64	PJA 331	2.7	4.1	1.4	0
65	PBP 351	3.7	3.7	0	0
66	PJP 377	4.7	5.7	1.0	0
67	PBA 3R3	2.5	3.9	1.4	1
68	PBP 351	3.7	3.6	- .1	1
69	PBP 3R1	3.6	3.4	- .2	0
70	PBP 351	3.6	3.6	0	0
71	PJA 331	2.7	4.1	1.4	0

APPENDIX B

SAMPLE DATA

APPENDIX B-1

TRAVIS AFB C-141

#	MISSION NUMBER	1 SCHEDULED LENGTH	2 ACTUAL LENGTH	2 - 1 DEVIATION	CODE WOP = 0 ADD = 1
007	PBP 5K1	3.7	4.5	.8	0
003	PBP 5K1	3.7	3.7	0	0
038	PBP 525	5.6	6.2	.6	0
001	PBP Y515	9.6	8.8	- .8	0
064	PBP 551	3.5	3.5	0	0
079	PBP Y555	11.9	10.6	-1.3	0
019	PBP Y515	6.0	5.5	- .5	0
117	PJA 5U3	5.1	5.4	.3	0
107	PAM 3917/03	5.7	8.4	2.7	1
011	PJA 5F3	3.5	7.3	3.8	0

APPENDIX B-2

CHARLESTON AFB C-141

#	MISSION NUMBER	1 SCHEDULED LENGTH	2 ACTUAL LENGTH	2 - 1 DEVIATION	CODE WOP = 0 ADD = 1
052	AJA 473	1.5	1.3	- .2	0
055	AJA 483	2.2	2.2	0	0
038	AEN 405	.2	.2	0	0
025	AJA 441	4.4	4.2	- .2	0
083	ABA 479	1.5	1.3	- .2	0
021	AEN 405/C	.2	.2	0	0
017	ABA 481	1.5	1.4	- .1	0
100	AJM 1762/01	.5	.5	0	1
048	AJA 451	3.1	3.3	.2	0
069	AJG 4066/Y2	1.3	1.3	0	1

APPENDIX B-3

TRAVIS AFB C-5

#	MISSION NUMBER	1 SCHEDULED LENGTH	2 ACTUAL LENGTH	2 - 1 DEVIATION	CODE WOP = 0 ADD = 1
15	PJA 3F1	2.9	4.0	1.1	0
17	PBP 351	3.7	3.8	.1	0
61	PJP 3K1	3.6	4.9	1.3	1
28	PEN 305	2.3	2.2	- .1	1
19	PBA 3F1	2.9	3.9	1.0	0
62	PEN 305	1.5	1.3	- .2	1
24	PJA 331	2.7	3.1	.4	0
37	PEN 305	4.5	4.5	0	1
44	PBP 351	3.6	4.2	.6	0
54	PEN 305	2.3	2.2	- .1	1

APPENDIX C

C-141 AND C-5 K-S TESTS FOR ALL MISSIONS

APPENDIX 6-1

TRAVIS AFB C-141

```
KOLMOGOROV-SMIRNOV TEST

FILE    TR141     (CREATION DATE = 05/07/80)    C-141 MISSION LENGTHS FROM
                                                       TRAVIS AFB
- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

     DIFF141
TEST DIST. - NORMAL (MEAN =        0.5600 STD. DEV. =        1.5728)

           CASES       MAX(ABS DIFF)       MAX(+ DIFF)       MAX(- DIFF)
             10            0.2394             0.2394           -0.1185

           K-S Z          2-TAILED P
           0.757             0.616
```

APPENDIX C-2

CHARLESTON AFB C-141

```
KOLMOGOROV-SMIRNOV TEST

FILE   CH141    (CREATION DATE = 05/07/80)   C-141 MISSION LENGTHS FROM
                                                 CHARLESTON AFB

- - - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

    DIFF141
TEST DIST. - NORMAL (MEAN =      -0.0500 STD. DEV. =       0.1269)

          CASES       MAX(ABS DIFF)       MAX(+ DIFF)       MAX(- DIFF)
             10           0.2532              0.2468           -0.2532

          K-S Z           2-TAILED P
          0.801             0.543
```

APPENDIX C-3

TRAVIS AFB AND CHARLESTON AFB C-141

```
KOLMOGOROV-SMIRNOV TEST

FILE   MAC141   (CREATION DATE = 05/07/80)   C-141 MISSION LENGTHS FROM
                                            TRAVIS AFB AND CHARLESTON AFB
- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

    DIFF141
TEST DIST. - NORMAL (MEAN =       0.2550 STD. DEV. =       1.1302)

          CASES       MAX(ABS DIFF)      MAX(+ DIFF)      MAX(- DIFF)
             20           0.2893            0.2893          -0.1936

          K-S Z         2-TAILED P
          1.294            0.070
```

APPENDIX C-4

TRAVIS AFB C-5

```
KOLMOGOROV-SMIRNOV TEST

FILE   TRC5      (CREATION DATE = 05/07/80)   C-5 MISSION LENGTHS FROM
                                                   TRAVIS AFB

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

      DIFF5
TEST DIST. - NORMAL (MEAN =       0.4100 STD. DEV. =       0.5587)

            CASES       MAX(ABS DIFF)      MAX(+ DIFF)      MAX(- DIFF)
               10           0.2105             0.2105          -0.1545

            K-S Z           2-TAILED P
            0.666             0.767
```

APPENDIX D

C-141 AND C-5 T-TESTS
FOR ALL MISSIONS

APPENDIX D-1

TRAVIS AFB C-141

T-TEST(PAIRED SAMPLES)

FILE TR141 (CREATION DATE = 03/29/80) C-141 MISSION LENGTHS FROM TRAVIS 03/29/80 PAGE 2

- T - T E S T -

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	(DIFFERENCE) MEAN	STANDARD DEVIATION	STANDARD ERROR	CORR.	2-TAIL PROB.	T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
SCHD	SCHEDULED MISSION LENGTH	5.8300	2.021	0.892								
	10				-0.5600	1.573	0.497	0.030	0.003	-1.13	9	0.289
ACTUAL	ACTUAL MISSION LENGTH	6.3900	2.342	0.741								

APPENDIX D-2

CHARLESTON AFB C-141

T-TEST(PAIRED SAMPLES) 03/25/88 PAGE 2

FILE CH141 (CREATION DATE = 03/25/88) C-141 MISSION LENGTHS FROM CHARLESTON

- T - T E S T -

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	(DIFFERENCE) MEAN	STANDARD DEVIATION	STANDARD ERROR	CORR.	2-TAIL PROB.	T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
SCHD	SCHEDULED MISSION LENGTH											
		1.6400	1.320	0.417								
	10				0.0500	0.127	0.040	0.995	0.000	1.25	9	0.244
		1.5900	1.310	0.414								
ACTUAL	ACTUAL MISSION LENGTH											

APPENDIX D-3

TRAVIS AFB AND CHARLESTON AFB C-141

T-TEST(PAIRED SAMPLES) 03/25/80 PAGE 2

FILE MAC141 (CREATION DATE = 03/25/80) C-141 MISSION LENGTHS FROM TRAVIS AND CHARLESTON

- - - - - - - - - - - - - - - T - T E S T - - - - - - - - - - - - - - -

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	(DIFFERENCE) MEAN	STANDARD DEVIATION	STANDARD ERROR	CORR.	2-TAIL PROB.	T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
SCHD SCHEDULED MISSION LENGTH		3.7350	3.036	0.679								
	20				-0.2550	1.130	0.253	0.932	0.000	-1.01	19	0.326
ACTUAL ACTUAL MISSION LENGTH		3.9900	3.078	0.688								

APPENDIX D-4

TRAVIS AFB C-5

T-TEST(PAIRED SAMPLES) 03/25/80 PAGE 2

FILE TRC5 (CREATION DATE = 03/25/80) C-5 MISSION LENGTHS FROM TRAVIS

- T - T E S T -

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	(DIFFERENCE) MEAN	STANDARD DEVIATION	STANDARD ERROR	CORR.	2-TAIL PROB.	T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
SCHD SCHEDULED MISSION LENGTH		3.0000	0.869	0.275								
	10				-0.4100	0.559	0.177	0.890	0.001	-2.32	9	0.045
ACTUAL ACTUAL MISSION LENGTH		3.4100	1.167	0.369								

APPENDIX E

C-141 ADD-ON MISSION
NORMALITY TESTS

APPENDIX E-1

TRAVIS AFB C-141

KOLMOGOROV-SMIRNOV TEST

FILE TR141A (CREATION DATE = 05/07/80) C-141 ADD ON MISSION LENGTHS FROM TRAVIS AFB

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

TRADD141
TEST DIST. - NORMAL (MEAN = 3.9514 STD. DEV. = 2.4977)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
35	0.1172	0.1172	-0.0835

K-S Z	2-TAILED P
0.693	0.722

APPENDIX E-2

CHARLESTON AFB C-141

```
KOLMOGOROV-SMIRNOV TEST

FILE   CH141A   (CREATION DATE = 05/07/80)   C-141 ADD ON MISSION LENGTHS FROM
                                                          CHARLESTON AFB

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

     CHADD141
TEST DIST. - NORMAL (MEAN =       1.6298 STD. DEV. =       1.6047)

          CASES       MAX(ABS DIFF)      MAX(+ DIFF)      MAX(- DIFF)
            47           0.2344            0.2344          -0.1702

          K-S Z         2-TAILED P
          1.607            0.011
```

APPENDIX F

C-141 REGRESSION ANALYSIS

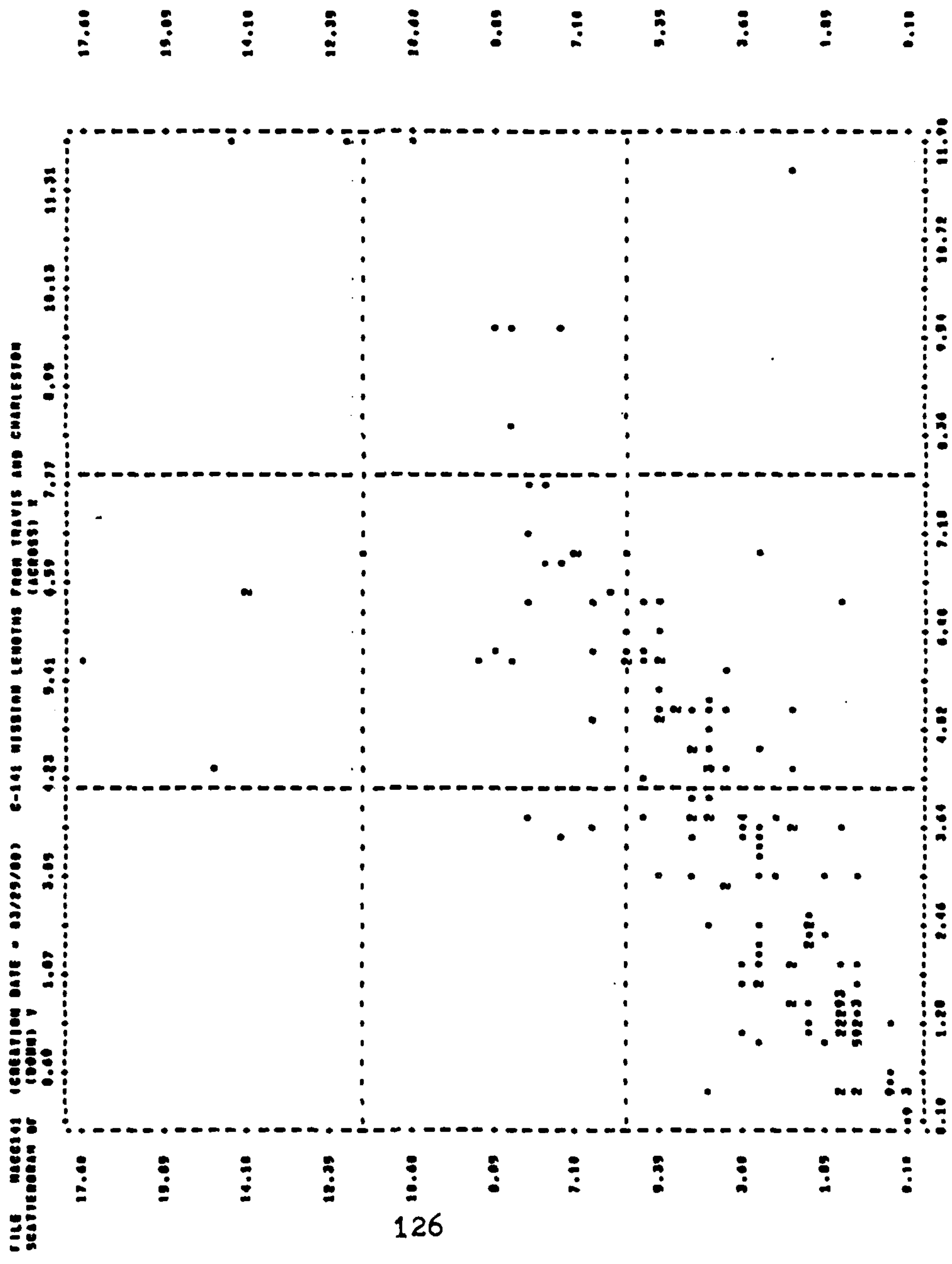
APPENDIX F-1

C-141 REGRESSION STATISTICS

```
SIMPLE LINEAR REGRESSION                                                              03/25/80       PAGE    4

FILE    MACC141  (CREATION DATE = 03/25/80)   C-141 MISSION LENGTHS FROM TRAVIS AND CHARLESTON

* * * * * * * * * * * * * * * * * * * * * * * *  M U L T I P L E    R E G R E S S I O N  * * * * * * * * * * * * *    VARIABLE LIST  1
                                                                                                                   REGRESSION LIST  1
DEPENDENT VARIABLE..     Y

VARIABLE(S) ENTERED ON STEP NUMBER  1..     X

MULTIPLE R            0.82026                      ANALYSIS OF VARIANCE     DF       SUM OF SQUARES        MEAN SQUARE            F
R SQUARE              0.67283                      REGRESSION                1.          1424.18514         1424.18514        450.37752
ADJUSTED R SQUARE     0.67134                      RESIDUAL                219.           692.52246            3.16220
STANDARD ERROR        1.77826

----------------- VARIABLES IN THE EQUATION ------------------          ------------- VARIABLES NOT IN THE EQUATION -------------

VARIABLE              B            BETA      STD ERROR B        F          VARIABLE       BETA IN      PARTIAL   TOLERANCE          F
X                0.9936839      0.82026        0.04682       450.378
(CONSTANT)       0.3187225

MAXIMUM STEP REACHED

STATISTICS WHICH CANNOT BE COMPUTED ARE PRINTED AS ALL NINES.
```

APPENDIX F-2

C-141 SCATTERGRAM



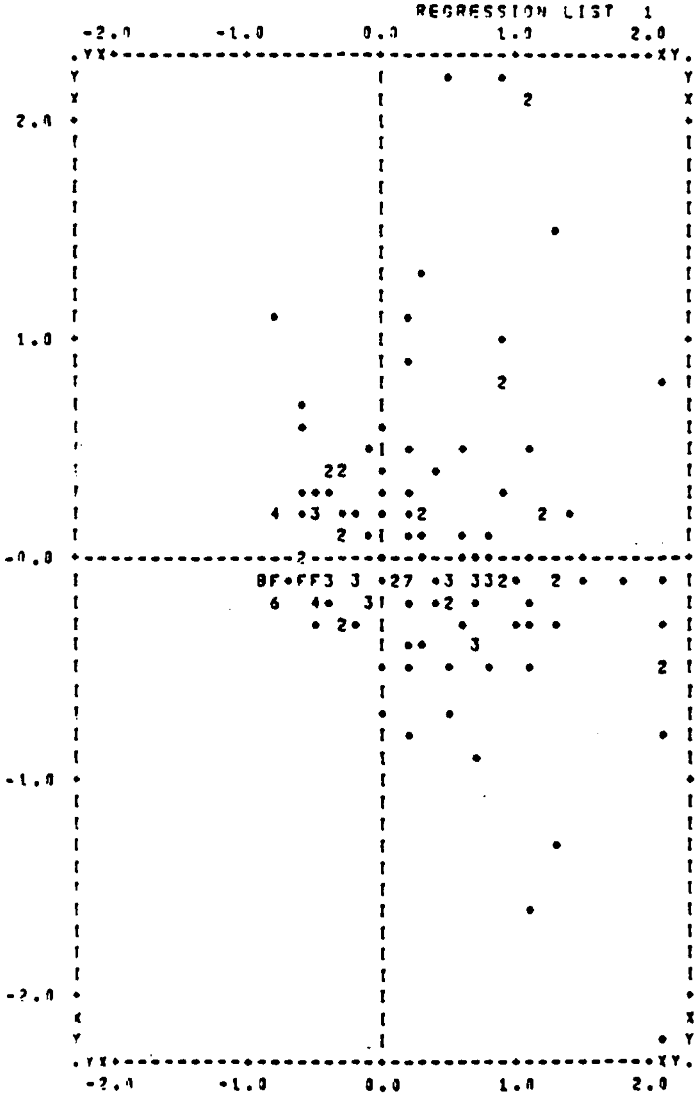
APPENDIX F-3

C-141 STANDARDIZED RESIDUAL PLOT

FILE MACC141 (CREATION DATE = 03/25/90) C-141 MISSION LENGTHS

* * * * * * * * PLOT STANDARDIZED RESIDUAL (DOWN) -- PREDICTED ST.

DEPENDENT VARIABLE Y VARIABLE LIST 1
REGRESSION LIST 1



APPENDIX G

C-5 REGRESSION ANALYSIS

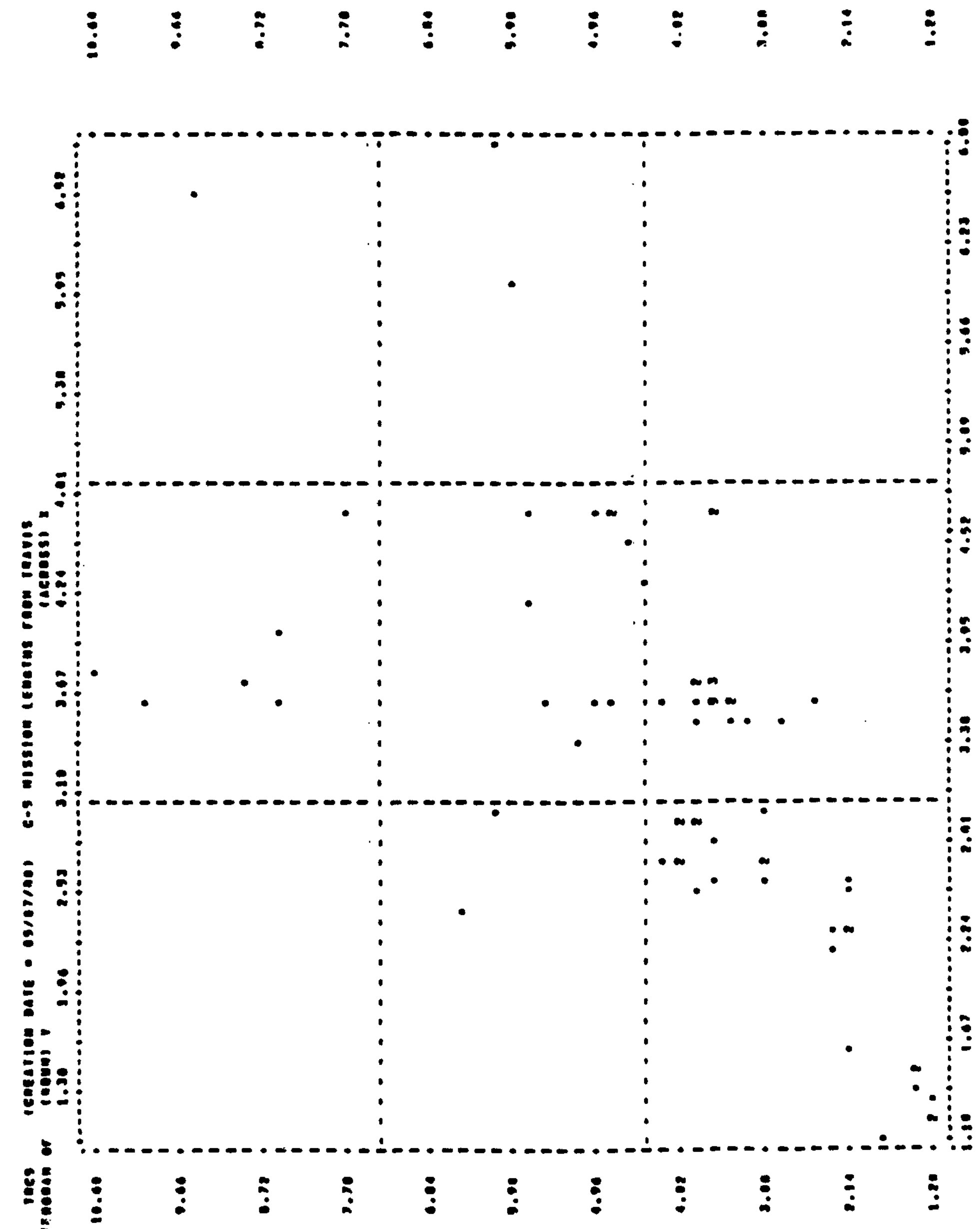
APPENDIX G-1

C-5 REGRESSION STATISTICS

```
SIMPLE LINEAR REGRESSION                                                  05/07/88        PAGE    4

FILE    TRCS     (CREATION DATE = 05/07/88)   C-5 MISSION LENGTHS FROM TRAVIS

* * * * * * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * *   VARIABLE LIST  1
                                                                                                                       REGRESSION LIST  1
DEPENDENT VARIABLE..    Y

VARIABLE(S) ENTERED ON STEP NUMBER  1..     X

MULTIPLE R           0.61576                    ANALYSIS OF VARIANCE    DF      SUM OF SQUARES       MEAN SQUARE           F
R SQUARE             0.37916                    REGRESSION               1.         114.90448          114.90448        42.13942
ADJUSTED R SQUARE    0.37016                    RESIDUAL                69.         188.14787            2.72677
STANDARD ERROR       1.65129

----------------- VARIABLES IN THE EQUATION ------------------         ------------- VARIABLES NOT IN THE EQUATION -------------

VARIABLE              B           BETA      STD ERROR B        F       VARIABLE       BETA IN      PARTIAL    TOLERANCE
X                 1.1222903     0.61576       0.17289       42.139
(CONSTANT)        0.4350180

MAXIMUM STEP REACHED

STATISTICS WHICH CANNOT BE COMPUTED ARE PRINTED AS ALL NINES.
```

APPENDIX G-2

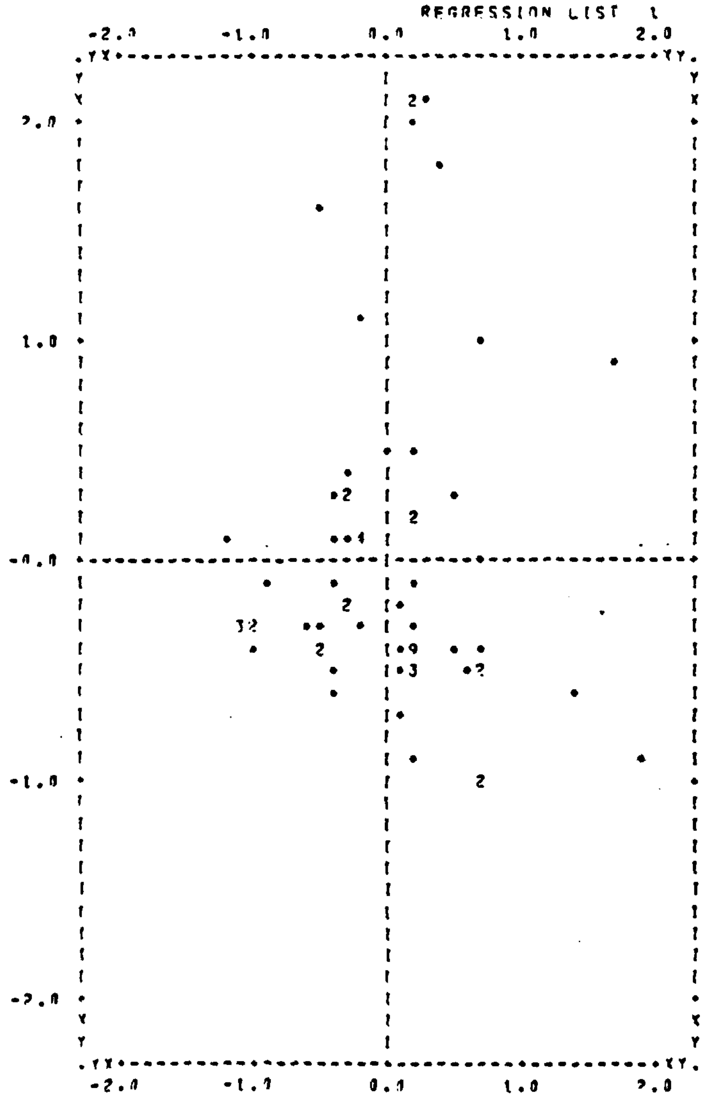
C-5 SCATTERGRAM



APPENDIX G-3

C-5 STANDARDIZED RESIDUAL PLOT

```
FILE    TRC5      (CREATION DATE = 05/07/80)    C-5 MISSION LENGTHS

* * * * * * * *  PLOT   STANDARDIZED RESIDUAL (DOWN) -- PREDICTED S

DEPENDENT VARIABLE    Y             VARIABLE LIST  1
                                    REGRESSION LIST  1
```



APPENDIX G-4

C-5 MISSION LENGTHS

SIMPLE LINEAR REGRESSION

FILE TRC5 (CREATION DATE = 05/07/80) C-5 MISSION LENGTHS FROM TRAVIS AFB

VARIABLE	MEAN	STANDARD DEV	CASES
X	3.3183	1.1416	71
Y	4.1592	2.0807	71

APPENDIX H

CALENDARS

APPENDIX H-1

COMBINED INDIVIDUAL SCHEDULES
BLANK EXAMPLE

PILOT A	PILOT B	PILOT C	PILOT D	PILOT E	PILOT F	PILOT G	PILOT H	PILOT I

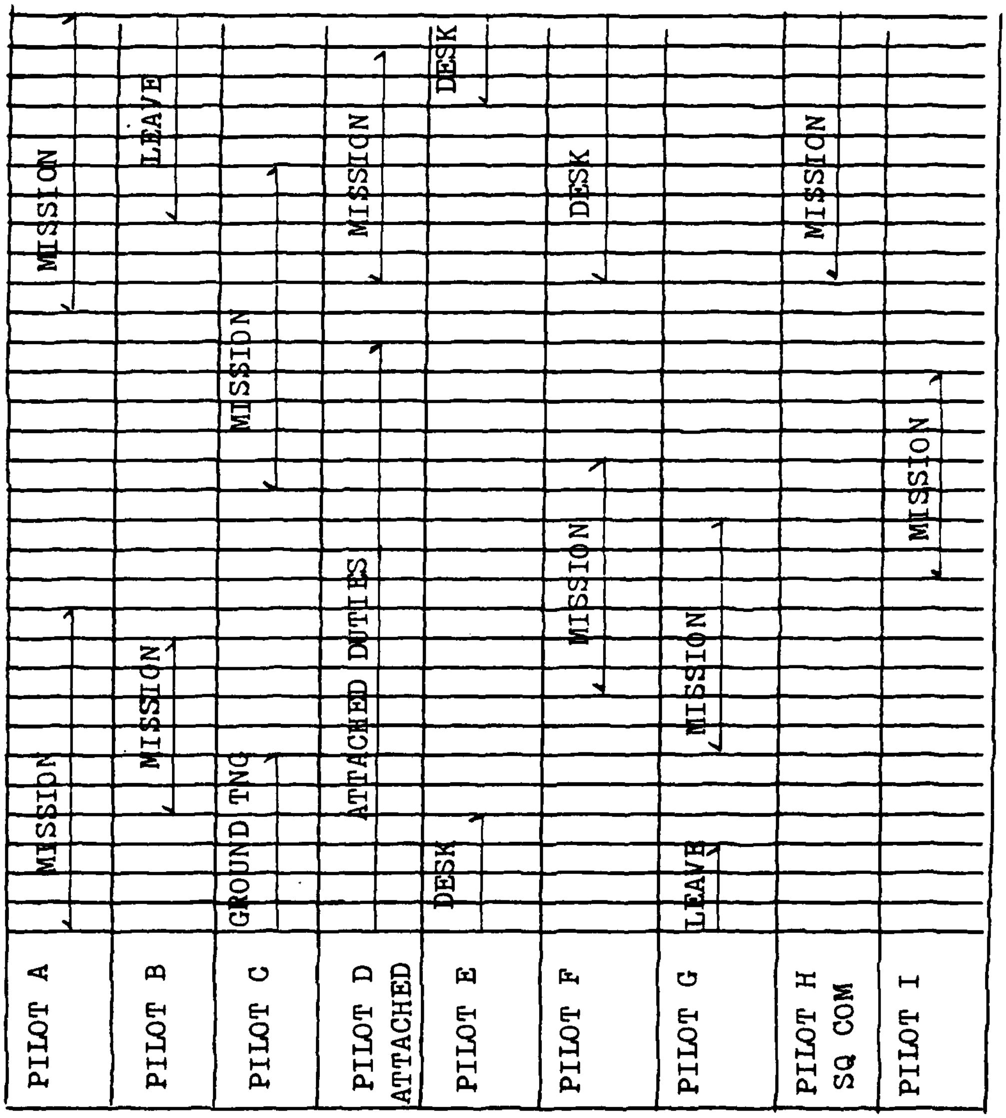
APPENDIX H-2

MISSION CALENDAR

MISSION CALENDAR				MONTH		
SUN	MON	TUE	WED	THU	FRI	SAT

APPENDIX H-3

COMBINED INDIVIDUAL SCHEDULES
WITH WOP MISSIONS



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DATE
FILMED

9-8